BULLETIN

OF THE

Society for the Promotion of Engineering Education

Published under the supervision of the Publication Committee:

H. S. JACOBY, ANSON MARSTON, F. L. BISHOP, *Editor*.

Address all communications to the Editor, University of Pittsburgh, Pittsburgh, Pa.

VOL. VI LANCASTER, PA., FEBRUARY, 1916 No. 6

TABLE OF CONTENTS.

Editorial 356
Monthly Letter 356
Society Notes 358
New Members 359
Applicants for Membership 360
Other Societies 360
Books Received 361
Book Reviews 362
College Notes 365
The Sag of the Second Year, by Sada A. Harbarger 374
Vector Notation, by W. V. Lyon 381
Compound Technical Terms, by Dan E. Carpenter 401
The Task for the Teacher, by F. E. Sanborn 406
The Energy Equation of Turbines, by R. F. Deimel 413
The Classification, Denotation, and Filing of Electrical Engineering Apparatus, by F. C. Caldwell 418
Freshman Courses in Orientation, by W. H. Kenerson 423
Progress Report of Committees 428

SOCIETY NOTES.

THE COMMITTEE OF EXPERTS.

Early in the fall President Jacoby of this Society was asked by the Secretary of the Navy to suggest the names of five experts in education to visit the Naval Academy and consult with the officers in regard to the work of that institution. The following men were appointed on this committee:

George F. Swain, Chairman; Past President, Society for the Promotion of Engineering Education; Past President, American Society of Civil Engineers; formerly Consulting Engineer, Massachusetts R. R. Commission; Chairman, Boston Transit Commission; Gordon McKay, Professor of Civil Engineering, Harvard University and Massachusetts Institute of Technology. (Representing Civil Engineering.)

Arthur N. Talbot, Past President, Society for the Promotion of Engineering Education; Past President, American Society of Testing Materials; Director, American Railway Engineering Association; Professor of Municipal and Sanitary Engineering, and in charge of Theoretical and Applied Mechanics, University of Illinois. (Representing Materials of Construction.)

L. P. Breckenridge, Professor of Mechanical Engineering, Sheffield Scientific School, Yale University; formerly Professor of Mechanical Engineering, University of Illinois; Designer of the Dynamometer Car; and Director of Tests for various railroads operating in the State of Illinois. (Representing Mechanical Engineering.)

Vladimir Karapetoff, Professor of Electrical Engineering, Cornell University; Author of Works in Electrical Engineering; Formerly in Engineering Department, Westinghouse Electric & Manufacturing Company; Chairman, Education Committee of the American Institute of Electrical Engineers. (Representing Electrical Engineering.)

F. L. Bishop, Secretary, Society for the Promotion of Engineering Education; Professor of Physics, and Dean, School of

Engineering, The University of Pittsburgh. (Representing the Pure Sciences.)

These men visited the Naval Academy on January 27, 28 and 29 and at this visit made a study of the post-graduate work. Messrs. Swain and Bishop were appointed by the Committee to present the report to the Secretary of the Navy as soon as it is completed.

A CORRECTION.

In President Jacoby's discussion of "Economy in the Use of Class Rooms," in the January BULLETIN, page 347, the column headings of the tabular data are incorrectly set. This should appear as below:

	Average Use per Room in		Maximum Use per Room in	
	Hours per Week.	Hours per Day.	Hours per Week.	Hours per Day.
Recitation rooms	19.0	3.17	31.0	5.17
Drafting rooms	21.9	3.65	35.0	5.83
Engineering laboratories	15.0	2.50	22.5	3.75

NEW MEMBERS.

BLACK, H. F., Professor of Mathematics, and Assistant Professor of Engineering, Valparaiso University, Valparaiso, Ind.

COOPER, F. E., Member of Development Staff, Bird & Son, East Walpole, Mass.

DUCEY, E. J., Instructor in Civil Engineering, Pennsylvania State College, State College, Pa.

GRAY, ALEX., Professor in charge of Electrical Engineering Dept., Cornell University, Ithaca, N. Y.

JORDAN, H. H., Associate in General Engineering Drawing, University of Illinois, Urbana, Ill.

LAMPHRIES, V. D., Superintendent of Engineering Shops, Robert College, Constantinople, Turkey.

MACKENZIE, C. J., Professor of Civil Engineering, University of Saskatchewan, Saskatoon, Canada.

MCCANDLISS, E. S., Assistant Professor of Civil Engineering, Missouri School of Mines, Rolla, Mo.

MERRILL, J. L., Instructor in Mechanical Drawing, University of Colorado, Boulder, Colo.

OGLESBY, N. E., Instructor in Political Science, University of Virginia, University, Va.

PARK, C. W., Assistant Professor of English, University of Cincinnati, Cincinnati, O.

STANLEY, W. E., Assistant in Hydraulic Laboratory, Purdue University, LaFayette, Ind.

TUCKER, E. N., Instructor in Mathematics, University of Virginia, University, Va.

COLORADO SCHOOL OF MINES, Golden, Colo., Wm. S. Phillips, President.

UNIVERSITY OF VERMONT, Burlington, Vt., Guy Benton Potter, President.

APPLICANTS FOR MEMBERSHIP.

GRAHAM, P. H., Vanderbilt Fellow in Astronomy, University of Virginia, University, Va. E. J. Oglesby, N. E. Oglesby.

MCEACHNON, K. B., Professor of Electrical Engineering, Ohio Northern University, Ada, O. T. J. Smull, E. B. Thurston.

SNAVELY, T. R., Fellow of the Phelps-Stokes Foundation, University of Virginia, University, Va. E. J. Oglesby, J. S. Lapham.

STAPLES, E. I., Instructor in Electrical Engineering, University of North Carolina, Chapel Hill, N. C. R. L. James, P. H. Daggett.

OTHER SOCIETIES.

THE MATHEMATICAL ASSOCIATION OF AMERICA.

On December 30 and 31, 1915, there was held at Columbus, Ohio, the organization meeting of a new national mathematical association, the call for which had been signed by 450 persons representing every state in the union, the District of Columbia, and Canada. The object of the new association is to assist in promoting the interests of mathematics in America, especially in the collegiate field. It is not intended to be a rival of any existing organization, but rather to supplement the secondary associations on the one hand, and the American Mathematical Society on the other; the former being well organized and effective in their field, and the latter having definitely limited itself to the field of scientific research in the field of collegiate mathematics, however, there has been, up to this time, no organization and no medium of communica-

tion among the teachers, except the *American Mathematical Monthly*, which for the past three years has been devoted to this cause. The new organization, which has been named the Mathematical Association of America, has taken over the *Monthly* as its official journal.

There were 104 persons present at the organization meeting. The constitution and by-laws together with a full report of the proceedings will be published in the January issue of the *Monthly*. The following officers were elected:

President, Professor E. R. Hedrick, University of Missouri.

First Vice-President, Professor E. V. Huntington, Harvard University.

Second Vice-President, Professor G. A. Miller, University of Illinois.

Secretary-Treasurer, Professor W. D. Cairns, Oberlin College.

Publication Committee, Professor H. E. Slaught, University of Chicago, Managing Editor; Professor W. H. Bussey, University of Minnesota, and Professor R. D. Carmichael, University of Illinois.

These officers, together with the following, constitute the Executive Council: Professors R. C. Archibald, Brown University; Florian Cajori, Colorado College; B. F. Finkel, Drury College; D. N. Lehmer, University of California; E. H. Moore, University of Chicago; R. E. Moritz, University of Washington; M. B. Porter, University of Texas; K. D. Swartzel, Ohio State University; J. N. Van der Vries, University of Kansas; Oswald Veblen, Princeton University; J. W. Young, Dartmouth College; Alexander Ziwet, University of Michigan.

BOOKS RECEIVED.

Electric Railway Engineering. By C. F. Harding. Published by McGraw-Hill Book Co. 1916. Price $3.00 net.

Engineering as a Career. By F. H. Newell and C. E. Drayer. Published by D. Van Nostrand Co. 1916. Price $1.00 net.

BOOK REVIEWS.

Agricultural Drawing. By THOS. E. FRENCH, Professor of Engineering Drawing, and FRED. W. IVES, Instructor in Agricultural Engineering, both of Ohio State University. McGraw-Hill Book Co., Inc. 1915. Cloth, $1.25 net.

In this book, which covers a somewhat new field, the authors have successfully endeavored to place at the disposal of the practical farmer a short and yet complete course in engineering drawing and agricultural design which will enable him to get the maximum value out of his technical literature, intelligently plan and construct his buildings, survey and map his land and efficiently and economically manage his farm in accordance with the latest scientific methods. Many well-chosen problems of sound design with ample illustrations and various construction data tables add much to the value of the book. It is another excellent example of the recent tendency to write text-books which possess a distinct class room value and which at the same time appeal to the practical man out of school.

C. G. C.

Machine Elements and Power Transmission. By L. CHESTON STARKEY, M.E., Professor of Mechanical Engineering, Drexel Institute, Philadelphia, Pa. Published by the Author. 1915. 6×9, cloth. 132 pp., illustrated.

The author states that the purpose of his book "is to give the correct technical name and also to show the appearance and describe the function of many of the common machine elements and machine shop supplies in ordinary use and also in part II, to drill thoroughly on the foundation principles of mechanics underlying the transmission of power."

This purpose is well carried out in the text. A sketch of the part presents its appearance; a brief description indicates its technical name and use; accompanying tables and charts (which are simple and illuminating) show the stock sizes used in practical every day work.

The text is well suited for an introductory course or for a reference in courses in Machine Design.

W. R. W.

Principles of Dynamo-Electric Machinery. By BENJAMIN F. BAILEY, Professor of Electrical Engineering, University of Michigan. McGraw-Hill Book Company. New York. 1915. 6 × 9, cloth, 314 pages. Price $3.00 net.

This is a text-book for use by students who do not intend to follow electrical engineering as a profession. With this point in mind everything of a special nature has been eliminated and the mathematics reduced to a minimum. The aim of the author has been to give a clear physical conception of the phenomena which take place in electrical machinery.

After a short introductory chapter devoted to principles the author proceeds immediately to a description of the direct current motor and then to a discussion of the principles of direct current apparatus. Two chapters on alternating current circuits and meters follow and then a chapter devoted to each of the commoner types of alternating current machinery. About one hundred problems are included in the book.

The book suffers somewhat from an attempt to get too much in a small space. This is especially apparent in the direct current part of the book.

This text should be found useful for courses where the time is limited or as a preliminary course preparatory to more technical courses. Laboratory work is desirable in connection with the use of the book as a text.

R. L. G.

Directions for Designing, Making and Operating High Pressure Transformers. By Professor F. E. AUSTIN, Head of the Department of Electrical Engineering, Dartmouth College. Capitol City Press, Montpelier, Vt. 1914. 46 pages, illustrated. Paper, 5 × 8. Price 50c.

A practical booklet for the beginner in electrical engineer-

ing, giving explicit directions for building small capacity 110- to 10,000-, or 20,000-volt 60-cycle transformers.

H. E. D.

How to Make a Transformer for Low Pressures. By Professor F. E. AUSTIN, Head of the Department of Electrical Engineering, Dartmouth College. Northfield Publishing Co., Northfield, Vt. 1913. 14 pages, illustrated. Paper, 5×8. Price 25c.

An elementary pamphlet giving working directions for making 100 to 400 watts transformers, for student use, and practical application.

H. E. D.

PERSONAL.

The announcement has just been made of the retirement of Professor C. Frank Allen of the Massachusetts Institute of Technology under the benefit of the Carnegie Foundation to take effect at the close of the present academic year. Professor Allen has been connected with the institute as a member of the faculty for the past thirty years, and professor of civil engineering since 1896. He is a graduate of the Massachusetts Institute of Technology, class '72. In addition to a wide engineering experience he studied law and was admitted to the bar in New Mexico and Massachusetts.

Professor Allen has contributed materially to the development of engineering education in the United States. He was Secretary *pro tem* of the special committee on engineering education of the World's Engineering Congress in 1893 and was one of the founders of the Society for the Promotion of Engineering Education. He was secretary of the Society in 1895–97; vice-president, 1898–99, president in 1903–04; and is a member *ex officio* of the present council.

COLLEGE NOTES.

Brown University.—Statistics drawn from the current catalogue of Brown University show that the institution is drawing students from a wider field than in the past. Forty-one per cent. of the 256 men in the record-breaking Freshman class come from Rhode Island, as against 49 per cent. in 1914–15. Massachusetts contributes 23 per cent., and the six New England states 73 per cent., as against 80 per cent. a year ago. Five other states, New York, New Jersey, Pennsylvania, Ohio, and Illinois, contribute 20 per cent., a 5 per cent. increase.

The composition of the undergraduate men's college as a whole remains preponderatingly of local students. Fifty-four per cent. of the student body live within 25 miles of the University, and only 34 per cent. more than fifty miles away. The Women's College is more distinctly a local institution, drawing 78 per cent. of its students from within the 25-mile radius. Of the 150 students in the Graduate Department exactly two-thirds are Rhode Islanders, and 29 different colleges are represented among the 55 who did not graduate from Brown.

University of Illinois.—The College of Engineering gave short courses in ceramic engineering from January 10 to 22, and in highway engineering from January 10 to 21. Registration in both courses was large and in excess of previous years.

A departmental engineering library is to be established in the Engineering building within the near future. The Department of Architecture has maintained an architectural library for a number of years in this building, but other departments of the college have been served by the general library. The latter is housed in a building erected in 1897 for an institution of five hundred students and is entirely inadequate for an institution with ten times the enrollment originally provided for. Accessions are being made on the large scale with the object of building up the collection to a mini-

mum of one million volumes. A new library building to involve an expenditure of a sum in excess of one million dollars is planned by the board of trustees. Construction will begin within a period of two years.

Recent additions to the engineering staff include: C. Stanley Sayle as assistant to the director of the engineering experiment station and as instructor in civil engineering; O. S. Beyers as first assistant in the engineering experiment station of the department of railway engineering.

After a year of deliberation and discussion, the faculty of the College of Engineering has adopted the following recommendations in regard to rhetoric:

1. "Rhetoric 1 and 2 shall hereafter be a prerequisite for junior standing in the College of Engineering, and no student in this college shall be permitted to register in more than eight hours of prescribed junior work without having passed as being registered in Rhetoric 1 and 2."

2. "Any student in the College of Engineering whose written work shows that he is unable to use good English shall be reported by his instructor to a standing committee of the College of Engineering appointed for this purpose, which committee shall have the authority to direct the student to take as a prerequisite for graduation such additional instruction in rhetoric as may be prescribed by the department of English."

Trygve D. Yensen, formerly first assistant in engineering experiment station of electrical engineering has been promoted to the rank of assistant research professor in electrical engineering in recognition of his distinguished scientific achievement in developing a method for manufacturing a nearly chemically pure iron.

Mr. H. A. Wheeler, vice-president of the Union Trust Co. of Chicago, gave a lecture before the College of Engineering on "The Engineers' Profession as viewed from the Banker's Standpoint" on December 15, 1915.

Lafayette College.—For the purpose of the more efficient handling of matters pertaining to the technical and academic

sides of the work at the college, the general faculty at Lafayette College has been divided into two councils. Each council is composed of faculty members with the rank of assistant professor or higher. These councils will meet from time to time for the purpose of discussing problems belonging purely to one side of the college or the other. Professor James T. Rood is chairman of the engineering council.

The department of civil engineering is busily engaged in making tests for committee C–1 of the American Society for Testing Materials. The civil department has installed a power concrete mixer. Professor J. Madison Porter, head of the department of civil engineering, is planning to organize an advisory board, composed of practical men in various lines of civil engineering. The purpose of this move is to cause the work of the department to meet, more accurately, the needs of the engineering world. The department of electrical engineering has received a gift from Lyman C. VanInwegen of the class of 1915. It consists of a set of the most interesting telephone instruments, comprising a part of the private line installed before there were public telephones. This gift completes an exhibit of apparatus showing the development of the telephone system.

Professor E. O. Fitch of the mechanical engineering department is perfecting the details for the inauguration of a cooperative courses at Lafayette. It is expected that this new feature of the work at Lafayette will go into operation in the early part of the coming summer.

A course in chemical engineering has been worked out and will be open to students at Lafayette beginning with the next college year. The course will be under the direction of Professor Edward Hart. It will continue very largely the work in chemistry which has been given in that department and will also include a rather complete curriculum of purely engineering subjects.

New Mexico College of A. and M. Arts.—The Engineers' Club of New Mexico State College made an inspection trip

to El Paso in October, visiting the Southwestern Portland Cement Co., The International Brick Co., The Traction Co.'s power plant, The Globe Mills, and the El Paso Southwestern R. R. shops. The trip was largely attended and the most successful one yet conducted. The school of engineering has just purchased an up-to-date moving picture machine which will be used for both lecture-room and social purposes. Through the courtesy of the General Electric Company, moving pictures of the Panama Canal were shown at the last meeting. This marks the beginning of a series of motion pictures of an educational nature at this institution. The mechanical engineering department has just constructed a submerged condenser to be used in test work in the School of Engineering. A feature of this condenser is the use of concrete as a shell.

The Ohio State University.—The engineering lecture course has so far included the following: Nov. 5, S. W. Stratton, director of the U. S. Bureau of Standards, on the work of the bureau in its various phases. Nov. 19, Osborn Monnett, engineer with the American Radiator Company, on "The Elimination of Smoke." Dec. 9, Dr. C. E. Kenneth Mees, director of the Research Laboratory of the Eastman Kodak Co., on "Fundamentals of Photography." Lectures scheduled for the future are: Feb. 18, Frank P. Gilbreath, consulting engineer, Providence, R. I., on "Motion Study Methods of Reducing Time, Motions and Fatigue of Operators." March 3, H. A. Toulmin, patent attorney, of Dayton, O., on "Munitions of War."

Leaving Columbus February 15, Prof. F. H. Eno, of the department of civil engineering, will visit the following universities, to inspect their methods of instruction in sanitation, water supply and municipal engineering in general: Cornell, Massachusetts Institute of Technology, Columbia, Pennsylvania, Michigan, Illinois, Purdue, Wisconsin, Minnesota, Iowa, Kansas, Missouri and Texas.

Weather forecasts are being distributed daily from the Uni-

versity Wireless Station to all operators throughout the state. The forecasts are received at the university by phone from the local weather bureau. The wireless station is being enlarged from one kw. capacity to five kw.

A new curriculum leading to the degree of bachelor of engineering has been added. The first two years are based upon fundamental work and the last two years comprising 68 hours, all elective with the exception of 10 hours in mechanics. This curriculum is to serve the double purpose of offering students the opportunity of selecting special lines of engineering and also to give opportunity to take a limited amount of cultural work. The total enrollment in the engineering college last year was 851. This year it is 932.

Dean Edward Orton, Jr., is away from the university on a year's leave of absence. Professor E. F. Coddington is acting dean during this period. Professor C. T. Morris, civil engineering, is on a leave of absence for six months.

The office of assistant to the dean has been created in this college and is filled by Professor C. C. Morris, mathematics department.

Panfilo Trombetta, a 1915 graduate from the electrical engineering department, has been granted the Robinson Fellowship and is engaged in a study of the effect of frequency upon the apparent inductance of coils.

A new course in advanced industrial chemistry, under instruction of Dr. J. R. Withrow, has been added to the graduate school, with a present enrollment of six members.

Mr. E. C. Bain, graduate of 1912, formerly assistant chemist in the Bureau of Standards, has been made graduate assistant in industrial chemistry this year. T. O. Farmer, formerly with the Cutler Hammer Mfg. Co. of Milwaukee, and W. C. Dyer, teacher at Mr. Vernon, O., have been appointed assistants in electrical engineering, taking the place of L. W. Frost, who has accepted a position with the Columbus Ry., Pr. & Lt. Co. A. A. Ashinger, graduate of Purdue University, has been appointed assistant in the department of mechanics.

Professor C. C. Morris has been promoted from assistant professor to professor in mathematics. G. F. Schlesinger and R. C. Sloane, civil engineering, and W. D. Turnbull, engineering drawing, have been promoted from instructors to the position of assistant professors.

The ceramics department in conjunction with the metallurgical department has just installed a carbon resistance electric furnace, Hoskins Type FC 104, for the study of refractory values of fire clays and investigation of high temperature metal alloys.

Prof. F. C. Caldwell, electrical engineering, has been appointed a member of the illuminating engineering committee of the Ohio Electric Light Association.

University of Pennsylvania.—The United States Bureau of Mines recently published the Bulletin "Notes on the Use of Low Grade Fuel in Europe," by Dr. R. H. Fernald, professor of dynamical engineering. This bulletin represents the work of Dr. Fernald, done under a commission issued to him by the United States Bureau of Mines to investigate the use of low grade fuel in Europe. Dr. Fernald spent several months on this commission in the British Isles, Belgium and Holland, intending to make further research in Germany, Norway, Sweden, Russia, Austria-Hungary, Italy and France, but was prevented owing to the breaking out of the European war. However his notes on low grade fuel in the British Isles, Belgium and Holland are very complete, probably the most comprehensive ever published in this country.

The following lectures have been delivered before the senior and junior classes in engineering: Oct. 29, 1915, "Conservancy in China," by Dr. A. P. Davis, U. S. Reclamation Service; Nov. 19, 1915, "Industrial Safety," by Mr. W. P. Barba, Vice-President, Midvale Steel Company; Dec. 17, 1915, "Explosives as an Aid to Engineering," by Dr. Charles E. Monroe; Jan. 21, 1916, "The Transportation of Explosives," by Col. B. W. Dunn.

Messrs. G. S. Wheatley, G. B. Wharen and P. J. Kiefer, of

the mechanical engineering department, were away several days during the Christmas recess on a performance test of the power plant of the Dexter Portland Cement Co. at Nazareth, Pa., for Mr. A. C. Wood, consulting engineer.

Dr. Harold Pender, professor of electrical engineering has recently been appointed secretary of the Standards Committee of the American Institute of Electrical Engineers.

Prof. C. E. Clewell delivered a lecture before the Woman's Civic Club of Philadelphia on December 10, 1915, on the subject "Home Lighting as a Fine Art" and presented a paper on the "Illumination of Factory Buildings" before the York Engineering Society of York, Pa., on the evening of December 12, 1915. Each of these lectures was illustrated by experiments relating to the fundamental principles of artificial lighting.

Mr. R. J. Daly, of the Electrical Engineering Department, spent the two weeks of the Christmas recess in Detroit, Mich., on telephone appraisal work with Mr. E. P. Burch, consulting engineer. This is a continuation of similar work begun during the past summer.

The Pennsylvania State College.—Dean R. L. Sackett attended the annual meeting of the American Society for the Advancement of Science and took part in the discussions. This meeting was held in Columbus, Ohio, Dec. 26–31. Dean Sackett was also delegate to the national conference of the Phi Kappa Phi honorary fraternity, of which President E. E. Sparks is national president.

The foundation for a new 100 H.-P. Kerr steam turbin has been built in the mechanical engineering laboratory. This turbine will be used as a part of the laboratory equipment to which it will be a valuable addition.

On January 14, Professor Edgar Marburg, Head of the Department of Civil Engineering of the University of Pennsylvania, lectured on Cantilever Bridges.

Professor Diemer and Professor Resides, of the School of Engineering, attended the State Educational Association

meeting at Scranton, December 28–30. Professor Resides presented a paper on wood-turning.

The work in Engineering Extension has met with great success during the past semester. Classes in shop mathematics and shop drawing have been organized in Kane, Ridgway, DuBois, and Tyrone in which places extension work had not been previously undertaken. New classes were also established at Wilmerding, Connellsville and Pittsburgh. At Connellsville there is a large class in Power Plant Economics conducted by Mr. Burr, of the Mechanical Engineering Department. Mr. C. F. Kopp is in the Pittsburgh district organizing classes in the railway shops. The locomotive engineers and firemen of Pittsburgh have suggested that a course in locomotive operation be given. If this class is organized it will be conducted by Professor A. J. Wood, who will use his new book on that subject as a text. Mr. N. C. Miller is at present establishing new classes in Sunbury and at the navy yard of Philadelphia where the Secretary of the Navy has authorized the introduction of extension classes.

The Case Threshing Machine & Engine Company of Wisconsin is sending a 12- to 24-horsepower gas tractor for experimental use in the School of Engineering.

Dean R. L. Sackett attended the recent annual meeting of the American Society of Civil Engineers held in New York City and inspected the new Catskill water supply system.

Professor E. D. Walker was recently made a non-resident director of the Engineers' Society of Pennsylvania for a term of three years.

Throop College of Technology.—Preliminary plans for the chemistry building at Throop College of Technology, in Pasadena, have been completed, and the architects, Mr. Elmer Grey, of Los Angeles, and Mr. Bertram G. Goodhue, of New York City, are at work on the complete detailed plans and specifications of the building, Mr. Grey acting as architect in charge, with Mr. Goodhue as consultant. The building is to cost $60,000 and construction will be begun probably within

thirty days. The building is to be ready for occupancy next September, and Dr. Arthur A. Noyes will inaugurate his research work in the new laboratory about December, 1916. Dr. Noyes has just returned to Boston after a few weeks' stay in Pasadena, which time was spent in working out plans for the building, and for the development of the department of chemistry, and the special research laboratories.

Throop College is the recipient of the very beautiful replica in bronze of the statue of Nathan Hale, by Bela Lyon Pratt on the Yale campus, which was on exhibition at the Palace of Fine Arts during the San Francisco exposition.

University of Washington.—Thirty-three mining men, with experience varying from one to twenty-five years, have enrolled in the nineteenth annual three months' short session at the College of Mines, University of Washington, Seattle.

At the annual smoker tendered the short session miners by the student branch of the American Institute of Mining Engineers, Captain R. H. Stretch of the Alaska Bureau, Seattle Chamber of Commerce, delivered an address on "The Mineral Belts of Alaska."

THE SAG OF THE SECOND YEAR.

BY SADA A. HARBARGER,

Assistant in English, University of Illinois.

Though noted by teachers of engineering students everywhere, the sag of the second-year men has received no explanation. Indeed, Dean Anthony and Mr. Humphreys after a study of the grades of students during the four years spent in the University have desired an explanation of this fact. And Dr. C. R. Mann in the Report of Progress in the Study of Engineering Education sets forth the general conclusion of teachers of engineering students when he says: "Figures show that the schools realize that even the proficient students who are on the whole considered worthy of graduation have not done good work in physics, mechanics, foreign languages, calculus, English, and chemistry." These subjects, it seems, are in the majority of schools given in the second year of an engineering course; consequently teachers everywhere should have the same experiences.

The reason for the sag of the second year, which has puzzled many, does not, however, seem to be hidden. Moreover, I should like to offer an explanation which is based upon my observations and my conservations with second year men from the College of Engineering. These men I have met for the past years, as I have taught them freshman rhetoric. Some may perhaps say that since I have taught a subject for which the technical student has a proverbial aversion, my inferences lack force. Yet Dr. Mann has noted that the sag or, I should say, the attitude which might make for the second year sag, is noticeable in "physics, mechanics, foreign languages, calculus, chemistry," as well as in English, or—as it is indicated in some college—rhetoric. The experiences of a teacher of

rhetoric are as likely, therefore, to be typical as those of an instructor of any one of the other subjects enumerated above.

But before giving an explanation of this sag, it will perhaps be well to describe the means by which I have arrived at my method of teaching English to engineers. During the eight years I have taught rhetoric to engineering students, my aim has not been to foist the subject upon unwilling victims, but to put the subject on as practical a basis as possible. Not so much by having students think engineering and write engineering, but by instilling into my students a high respect for the profession of engineering, I have endeavored to make them see things outside of their profession as well as within from the engineering point of view. In other words, I have tried to make them catch that second demand which Dr. Mann notes "is prominent in the professional criticism of engineering schools—the engineer's breadth of view—the demand for men with vision, enthusiasm, and sympathy,—men with ideals and faith in human nature." Or to put my purpose concretely, to make something beside "the technical details of any subject the sole inheritance of the engineer."

Naturally, I did not arrive at my aim of giving an engineer breadth of view immediately. I began, in fact, with the opposite theory. I started to stimulate interest by the use of shop reports, the presentation of data, and other material closely related to engineering. The results proved unsatisfactory for two reasons: (1) I found that I did not have the technical information which would make me competent to criticize the material. (2) I discovered by this attempt to cater solely to engineering interests that my students, in spite of their own ideas to the contrary, had not yet reached the point in their education where they were deeply interested in or could handle a detailed study of some specific problem. Their training even in the fundamentals of engineering had not been such as to foster a special interest. For instance, though a student was registered in Electrical Engineering, he had, no matter how thoroughly he considered himself to be

steeped in this one branch, little or no grasp of the problems peculiar to electrical engineering. I found by assigning such subjects as *The Location or the Equipment of a Power Plant,* etc., that the student was very much confused, even overwhelmed by these subjects, though his talk had seemed to indicate some knowledge of them. He also complained that he had had nothing in his engineering course that would lead to any knowledge or understanding of the special problems. But what surprised me more was the fact that, with all his enthusiasm for engineering abstractly, he seemed to have no eagerness to seize every opportunity to investigate, to record, and to inform others of the problems that belonged to his branch of engineering. The knowledge which he possessed, the knowledge which he had to impart was only general knowledge, in some instances, vague knowledge of the task to which he wished to devote his best energies. In spite of himself, he could follow only feebly a detailed discussion of a special problem. Though willing he was quite unprepared. He had no conception of just what were the interests of his elected branch of engineering. He was registered in Engineering—in Mechanical Engineering, or in Electrical Engineering; yet he had only a very hazy idea of the scope of either. Since both from the point of view of the student and of the instructor, the results proved unsatisfactory, I assigned simple subjects, many of which gave opportunity to recount personal experiences, such as *How Coal is Mined, How to Make Steel, A biographical sketch of some prominent engineer, The qualities of a good engineer,* etc. The students could handle these topics very creditably from the standpoint of information. Even, however, with these subjects which one might naturally conclude would make for some satisfaction, there was still discernible a spirit of unrest, of dissatisfaction, which is apparent in the writing of even the best students, regardless of the subject chosen—a general, vague handling of the subject, a confused sentence, a lack of attention to mechanical accuracy.

This dissatisfaction, this unrest puzzled me, for I believed

that rhetoric rightly taught could arouse the engineer. I had tried two plans. Still there was dissatisfaction. Working on the theory that a student writes freely in rhetoric not only when his interest is stimulated but also when his mind is not distracted by worries and questionings of one kind or another, I sought some explanation by probing my second-year students as I met them from time to time in personal conferences. And I found in every case, whether articulate or inarticulate, a state of dissatisfaction, of doubt, of confusion, of defiance toward themselves, toward their special course, toward the university, that attitude of mind which comes when anyone begins to do independent thinking. Often I got the spirit in such a remark as "I thought I wanted to be an engineer, but I can't see yet where all of these subjects I am having now apply to my course in engineering." When I questioned anyone of them upon his faith in himself, upon his philosophy of life, I came across the same baffled groping, the same lack of grip and oneness of purpose. The student was frequently painfully conscious of this slipping, this sag; but unaided he was unable to begin to explain much less to become master of himself.

One can make this spirit clearer, I believe, if one compares the attitude of the first-year and the second-year man. I have been exceedingly fortunate in being able recently to make such a comparison. On account of a change in arrangement of subjects, beginning with the present year, rhetoric has been made, for engineers, a first-year subject, not a second-year one. Until now my experience has been with second-year students. The instructor's point of attack is quite different. Fresh from the triumph of high school graduation, teeming with his dreams, amenable, the freshman comes to college to realize his dreams. Soon he finds that he is not getting what he thought he would get the first year; but he explains this lack through the fact that college is quite different from high school; that the relation of unrelated subjects to his particular interest will be apparent in his second year. So with faith that he

surely will realize his ambitions, that he surely will be led into the preliminary knowledge of his particular course the second year, he travels enthusiastically. An appeal to his dreams arouses his spirit; he responds quickly; he listens eagerly; he follows unafraid. No doubts disturb him. One has to take care that he does not waken too much intenseness. The problem is to restrain, not to arouse.

But what a marked contrast is the sophomore. I discovered that I could count on no unanimous coöperation if I attempted to win his interest by an appeal to his dreams. He sat back wary, scoffing, if not listless, as much as to say "I am not going to be taken by references to what I once thought. There is nothing in what I once dreamed. I know the disillusionment." Such an attitude on the part of the student indicates that he is experiencing in every direction, scholastically and ethically, the hardest year in his college career—the sophomore year. For with this year comes the trial by fire, the disillusionment—sometimes sudden and awful—which makes the whole world chaos.

A reason for this state seems to be that the fundamentals which the student is required to take in his second year indicate no nearer approach to his destination than did those of the first year. There is seldom a single course offered that is a specialized one. He has no identity. He is herded in these fundamental courses with men desiring nearly every subdivision of engineering. He still gets no closer view of his own, particular subject. He begins to question and to challenge the existing system; he wonders about his fitness for his course. Further inquiry reveals that the second-year man is assuming the same attitude towards everything—toward religion, toward conduct. He is temporarily without pilot or compass. He is going through his storm and stress period and suffering all of its tempests and calms. Naturally when one has upon his soul the problem of arriving at some working system of life, some reason for things as they are, one cannot apply himself with any degree of concentration to his studies.

On every side the great problem of harmonizing his ideals, his dreams, and the actual practice confronts him. He seeks amusements, dissipations, anything that will take him away from his problem. Thus are his poor grades made. For this reason do the grades of the second-year man sag. His soul has been put to a very severe test; he has made mistakes and low grades while he has been enduring this test. On no other grounds but these of this general upheaval in a man's soul does it seem possible to explain adequately this sag in the second-year man's work. It comes from the fact that, until his third year, an engineer's training is not specific, but general; that he is not made to feel that the fundamentals of the first two years have any direct bearing upon his own course. Indeed, little of the instruction of the first and second years of an engineering course in large schools is given by instructors of the engineering faculty. Sometimes it is given by those entirely out of sympathy with the technical student. Except by means of general weekly engineering lectures, the purpose of which is to present the varied forms of engineering, he gets little understanding of the whole field of engineering, much less comprehension of his own. He is not made to understand why the specific information for which he came to college is so long withheld.

Now, I am not saying that it is unwise to withhold the information so long. Indeed, I cannot suggest how the curriculum could be otherwise planned. I know of no way whereby the courses of study in engineering could be arranged as they are in some courses in agriculture, a scheme by means of which a student in beginning agriculture gets a preliminary course in each field before he undertakes his specialized work. I say I do not know how that could be brought about in engineering since mathematics, physics, etc., the foundations of the later structure of the specific engineering course, are not limited to engineering only. Perhaps there may be a method of teaching engineering students that could bring out definitely the real relationship of the fundamentals to their special course.

But I do say that this general training of the first and second year seems largely responsible for starting the train of thought that makes for a revolution in a second-year man's soul and shows itself in the sag of the second year. True this revolution comes into the life of any thinking person. It is a common experience. Nevertheless it is one that must be taken into account when dealing with engineering students, and one that must be considered as unique when dealing with the individual student. No teacher of second-year engineering students can ignore its influence upon a student's work. Indeed, the teacher, no matter what his attitude toward his business as an instructor, is obliged to take this psychological fact into account when dealing with his class. While all should possess the qualities of great teachers, it is especially necessary that those who teach second-year men should have faith, patience, sympathy, understanding, justness, vision. The way to eliminate the second-year sag, therefore, would appear to be found when a college can satisfactorily answer these two questions:

(1) Can the fundamentals of engineering be so taught as to make their relation to a specific branch of engineering apparent enough to hold the student's interest through two years?

(2) Are those who teach engineers the first two years of their college course the best teachers of these subjects that can be found?

VECTOR NOTATION.

BY WALDO V. LYON,

Instructor in Electrical Engineering, Massachusetts Institute of Technology.

To one, and especially a teacher, who solves problems dealing with any but the simplest of electric circuits, it soon becomes evident that a definite and logical notation is of great importance. This is particularly true when determining the characteristics of alternating-current electric circuits which have mutual inductance or capacity and which may also be in electrical connection. If the notation is logical and in accord with the physical phenomena which occur in elementary electric circuits, it will interpret the equations and vector diagrams that are used in the solution of problems dealing with the practical combinations of these elementary circuits with readiness and certainty.

The apparent ease and lack of careful definition with which vector diagrams are frequently drawn is often confusing, and the interpretation of the results may become so haphazard that the student has no clear conception of the actual physical phenomena which occur. In cases where the circuits are simple and there is little difficulty in explaining these physical phenomena, a definite notation does not appear to advantage, and indeed it may, at times, seem more cumbersome than is desirable. It should be said, however, that the application of such a notation will always require more precise thought. This argument alone should be a powerful one in its favor.

In regard to the symbols for generated electromotive force and potential difference, this distinction will be made. E represents a generated electromotive force of any sort; for

example, that due to chemical action or to electromagnetic induction. V represents a terminal potential difference which may be directly measured; for example, the terminal voltage of a battery or of an alternating current generator. In some cases E and V may be used to represent the same quantity, as in the case of an alternating current generator on open circuit. It is convenient, however, to have these two symbols, as in the case of apparatus under load conditions, so that one may be used to represent actual generated voltages and the other to represent terminal voltages.

In order that the notation shall have a clear and definite significance, the use of two subscripts is advised. By this means vectors can be defined completely. For example consider the circuit whose terminals are designated by the letters a and b. To say that a vector V represents the voltage or potential difference across the circuit is not sufficient, since this voltage may be measured either from a to b or from b to a, and these two voltages, although equal in magnitude, are directly opposite in phase. Likewise, to say that a vector I represents the current that exists in the circuit $a - b$ is not sufficient, since the current may be either from a to b or from b to a, and these two currents although equal in magnitude are exactly opposed in phase and produce opposite effects, both electrically and magnetically. That is these quantities, voltage and current, are completely defined only when both their magnitude and direction, or phase, are given, and a notation which does not recognize this is not a definite one.

In the case of circuits which are in no way related to others, it is often better to omit writing these double subscripts. If for example the circuit is so simple that we can without difficulty keep in mind a fixed direction through it, it will suffice to say that V is the voltage rise through the circuit (in that particular direction), and that I is the current existing in the circuit (in the same direction).

The vector method for solving alternating current prob-

lems is limited to those cases in which it is allowable to assume that all voltages and currents are simple harmonic functions of the time. Even with this limitation the method is of great use in determining approximate solutions. When the current and voltage are represented by Fourier's series, separate vector diagrams may be drawn for each of the harmonic components. This is seldom done.

The fundamental conception upon which the following conventions are based is this. The circuit for which the vector diagram is drawn is assumed to be *delivering* electric energy. Whether or not the circuit actually does deliver electric energy is shown by the phase relations of the vectors.

Convention for Voltage.—V_{ab} is the rise in potential through the circuit $a-b$ from the terminal a to the terminal b. If this is a positive quantity, b is at higher potential than a, and if it is a negative quantity, b is at a lower poten-

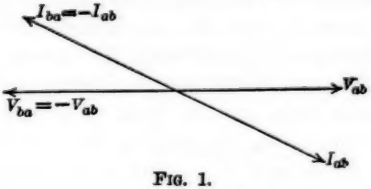

FIG. 1.

tial than a. When V_{ab} designates a vector, it signifies that, during the time the projection* of V_{ab} on the time axis is positive, b is at a higher potential than a, or that there is a rise in potential through the circuit from a to b. If V_{ab} represents the rise in potential from a to b, it is logical that $-V_{ab}$ should represent the fall in potential from a to b. Since when there is an actual rise in potential from a to b, there is an actual fall in potential from b to a, it follows that: $V_{ab}=-V_{ba}$. That is, changing the order of subscripts is equivalent to changing the sign of the vector. See Fig. 1. Since the difference in potential between two points is inde-

* This assumes that the vectors represent cosine functions.

pendent of the path taken between the points V_{ab} represents the potential rise across *any* circuit whose terminals are a and b.

Convention for Current.—I_{ab} is the current existing in the circuit $a - b$ in the direction from a to b. If I_{ab} is a positive quantity, the current is actually from a to b. If it is a negative quantity, the current is actually from b to a. When I_{ab} designates a vector it signifies that during the time the projection of I_{ab} on the time axis is positive, the current is actually in the direction from a to b. Since I_{ab} is the current from a to b and I_{ba} is the current from b to a, it follows that, as in the case of voltages, $I_{ab} = -I_{ba}$. The vector I_{ab} represents the current in one particular circuit from a to b.

Phase Relation of Voltage and Current in a Non-reactive Circuit.—The potential difference across a non-reactive circuit in which there exists a current is numerically equal to the product of the current and the resistance of the circuit. The phase relation of this potential difference and the current is determined by the fact that at any instant when the current is actually in the direction from a to b through the circuit, there is an actual fall in potential from a to b. That is, the fall in potential from a to b, viz., $-V_{ab}$, is equal to RI_{ab}, or it may be said that the rise in voltage, V_{ab}, across a non-reactive circuit is equal to $-RI_{ab}$. R is the resistance of the circuit between a and b.

Kirchhoff's Laws.—There are two laws of the electric circuit which are accredited to Kirchhoff that relate to the combination of voltages and to the combination of currents. In order that these shall be definite and in accord with our conventions for voltage and current they will be stated as follows:

I. The total rise in potential around any closed circuit is equal to zero.

II. At any junction the sum of the currents in a direction *toward* the junction is equal to the sum of the currents in a direction *away* from the junction.

These laws apply equally well to instantaneous values or to

the vectors which represent harmonic voltages and currents. Laws similar to these will also apply to magnetic circuits and to circuits which have electrostatic capacity.

Let a, b, c, etc., be consecutive points on any continuous electric circuit. The resultant rise in potential from a to x is equal to the sum of the rises in potential across the elements of the circuit between these points taken in the same direction. That is:

$$\text{I.} \qquad V_{ax} = V_{ab} + V_{bc} + V_{cd} + \cdots + V_{wx}.^*$$

If the points z and a are coincident the voltage between them is zero and the equation becomes a statement of Kirchhoff's first law.

$$V_{az} = 0 = V_{ab} + V_{bc} + V_{cd} + \cdots + V_{wx} + V_{xy} + V_{yz}.$$

Let $a - x$, $b - x$, $c - x$, etc., be electric circuits which meet at the common point x. The sum of the currents *toward* this point x, is equal to the sum of the currents *away* from the point. For example, this might be expressed by the following equation:

$$\text{II.} \qquad I_{ax} + I_{bx} + \cdots = I_{xn} + I_{xp} + \cdots.$$

This equation is a statement of Kirchhoff's second law. The solution for any current such as I_{ax}, is:

$$I_{ax} = I_{xb} + I_{xc} + I_{xp} + \cdots.$$

Convention for Power.—The electrical power *delivered by* the circuit, whose terminals are designated by the letters a and b, is equal to $V_{ab} \cdot I_{ab} \cdot \cos$ (angle between V_{ab} and I_{ab}). In this expression the first two quantities represent the scalar magnitudes of the voltage and current, but the angle is taken between the actual vectors which represent the potential rise through the circuit from a to b and the current existing in the circuit from a to b. With the preceding conventions for volt-

* Vector addition is of course understood.

age and current established, this convention for *power delivered* is simply a statement of fact.

Thus the phase relation of the rise in potential across any circuit, or part of any circuit, and the current in the direction of that rise is fixed solely by the power conditions in the circuit, or part of the circuit; and, vice versa, if this phase angle is known the power condition is at once determined. When the phase angle between the two vectors is less than ninety degrees, the circuit actually delivers electrical power. When the phase angle between the vectors is greater than ninety degrees, the circuit actually receives electrical power. See Fig. 2.

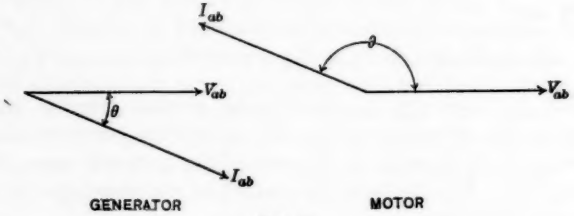

FIG. 2.

Series and Parallel Circuits.—Circuits may be connected electrically in series or in parallel. In the first case, the current is the same in magnitude and in direction around the circuit at all points, and thus at any point in the circuit the current may be represented by the same vector. In the second case, the potential rise from one terminal to the other is the same for each of the circuits in parallel and one vector may used to represent this quantity. This is in general the most logical procedure.

Electrostatic Circuit.—Fig. 3 represents a circuit which has only electrostatic capacity between its terminals a and b. Let us assume that there is a negative charge at a and a positive charge at b as indicated. The rise in potential from a to b, viz., v_{ab}, is then a positive quantity. If we further as-

sume that this capacity circuit is delivering electric power, *i. e.*, is discharging, the current through the circuit from a to b, viz., i_{ab}, must also be a positive quantity since $v_{ab} \cdot i_{ab}$, *i. e.*, the power delivered by the circuit, is a positive quantity. The current existing in the circuit is numerically equal to the ratio at which the charge is changing. Since the circuit is discharging the absolute value of the charge is diminishing, and if the current i_{ab} is to be equal to $+ dq/dt$, q must be a negative quantity and therefore it is the charge at a. Thus

$$i_{ab} = \frac{dq_a}{dt}.$$

Since the difference in potential between a and b is numerically

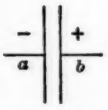

FIG. 3.

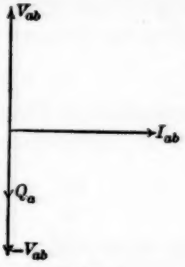

FIG. 4.

equal to the charge divided by the capacity, the rise in potential from a to b, viz., v_{ab}, which is a positive quantity, is equal to $-q_a/C$ for q_a is a negative quantity. Thus:

$$v_{ab} = -\frac{q_a}{C}.$$

If the charge is a simple harmonic function of the time, we have

$$q_a = Q_a \sin \omega t,$$

$$i_{ab} = \omega Q_a \cos \omega t,$$

$$v_{ab} = -\frac{Q_a}{C} \sin \omega t.$$

If the current and voltage are represented by vectors, their phase relation is shown in Fig. 4.

That is, the rise in potential across such a circuit from the terminal a to the terminal b is ninety degrees ahead of the current existing in the circuit from a to b. Observe that this is not the usual statement. It is often and loosely said that the current in such a circuit is ninety degrees ahead of the electro-motive force. The more exact statement is that the current from a to b is ninety degrees ahead of the fall in potential from a to b.

If a number of purely condensive circuits are connected together at an insulated point, o, the resultant charge at this point is a constant quantity. If the circuits are uncharged before being connected together, this resultant charge is zero, and in such a case we may write:

$$q_o' + q_o'' + q_o''' = 0.$$

This corresponds to Kirchhoff's second law, to which it may be reduced by differentiating.

$$\frac{dq_o'}{dt} + \frac{dq_o''}{dt} + \frac{dq_o'''}{dt} = 0.$$

This may be written as:

$$i_{oa} + i_{ob} + i_{oc} = 0.$$

It should be observed that this same current equation would have been obtained if there had been a resultant constant charge at the point of connection.

Magnetic Circuit.—As in the case of electric circuits, it is preferable to use double subscripts in connection with the symbol for flux. Thus ϕ_{ab} represents the flux in the magnetic circuit in the direction from a to b. If this is a positive quantity the north pole of a compass which is placed in the magnetic circuit between a and b would point towards b. If ϕ_{ab} is a negative quantity, the compass would point towards a. When ϕ_{ab} designates a vector it signifies that during the time the projection of ϕ_{ab} on the time axis is positive, the flux is

actually in the direction from a to b, *i. e.*, the north pole of the compass placed in the magnetic circuit between a and b would point towards b. As in the case of voltage and current, a reversal in the order of the subscripts is equivalent to a reversal in the sign of the vector representing the flux. Thus: $\phi_{ab} = -\phi_{ba}$.

Relation of Flux and Magnetizing Current.—In order to simplify the explanation, it will be assumed for the present that the flux in the magnetic circuit is at all times proportional to the magnetizing current which produces it. This precludes the ideas of saturation and of iron losses. It is sufficiently fundamental to suppose that the flux in the magnetic circuit is produced by the action of a magnetizing cur-

FIG. 5.

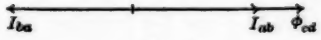

FIG. 6.

rent which exists in an electric circuit consisting of convolutions lying in planes approximately perpendicular to the direction of the flux. It is a fundamental convention of physics that, if the current appears right handed to an observer looking along the axis of a convolution, the flux is in the direction that the observer faces. If the current is left-handed, the direction of the flux is reversed. Thus in Fig. 5, if the current is actually from a to b, *i. e.*, right-handed to an observer at c, the direction of the flux, produced by the current is actually from c to d. This determines the phase relation of the flux and the current which produces it. If the current is right-handed

from the terminal a to the terminal b of the electric circuit, when observing the circuit along the direction of the flux from c to d, I_{ab} is in time phase with ϕ_{cd}, as shown in Fig. 6. When observed from c the winding is left-handed from b to a. Thus if the current is left-handed from the terminal b to the terminal a of the electric circuit, when observing the circuit along the direction of flux from c to d, I_{ba} is in time opposition to the flux, ϕ_{cd}, which it produces, as shown in Fig. 6.

Application of Kirchhoff's Laws.—The general principles expressed in these two laws of the electric circuit apply equally well to the magnetic circuit. It is only necessary to replace electromotive force, current and resistance by magnetomotive force, flux, and reluctance. This comparison is not exact since *all space* is magnetically conducting.

I. The total rise in magnetic potential around any closed magnetic circuit is zero.

II. At any junction the sum of the fluxes toward the junction is equal to the sum of the fluxes away from this junction.

I. The rise in magnetic potential along a magnetic circuit from c to d due to a magnetomotive force is approximately equal to $4\pi NI_{ab}$, where N is the number of turns in the magnetizing electric circuit between the points c and d, and I_{ab} is the current from the terminal a to the terminal b of this circuit. Strictly speaking, it is the integral of the force function from the point c to the point d. a and b are so taken that the electric circuit is right-handed from a to b when observed in the direction from c to d.

The *fall* in magnetic potential along a magnetic circuit from c to d due to the existence of a flux, ϕ_{cd}, is equal to $R\phi_{cd}$, when R is the reluctance of the magnetic circuit between c and d. Therefore, the rise in magnetic potential along a magnetic circuit from c to d due to the existence of a flux, ϕ_{cd}, is equal to $-R\phi_{cd}$, where R is the reluctance of the magnetic circuit between c and d.

If I_{ab} is the only magnetizing current and R is the total reluctance of the magnetic circuit, $4\pi NI_{ab} - R\phi_{cd} = 0$, *since*

the total rise around the circuit is zero. That is

$$4\pi N I_{ab} = R\phi_{cd}.$$

II. If a number of magnetic circuits meet at a common point, x, the sum of the fluxes toward this point is equal to the sum of the fluxes away from the point. Thus

$$\phi_{ax} + \phi_{bx} + \cdots = \phi_{xp} + \phi_{xq} + \cdots.$$

Electromagnetic Induction.—It will suit our purpose to divide electromotive force due to electromagnetic induction into two classes, which we will designate as "transformer" electromotive force and "rotation" electromotive force. It is not easy to give a simple and exact definition which will distinguish between these two classes and it will suffice to say that "rotation" electromotive force will only be considered when discussing commutating apparatus. There is need of making this distinction, however, since the phase relation of the first with respect to the flux which produces it, depends upon the direction of the flux and the direction, whether right- or left-handed, of the turns, while the phase relation of the second with respect to the flux which produces it depends upon the direction of the flux and upon the direction of rotation. Moreover, those two phase relations are not the same, the first being one of time quadrature, and the second one of time phase or of time opposition.

"Transformer" Electromotive Force.—Consider the magnetic circuit $c-d$ and the electric circuit $a-b$ that are shown in Fig. 5. Let us suppose that, due to the "discharge" of the magnetic field, the electric circuit, $a-b$, is *delivering* electric energy. The power delivered, $e_{ab} \cdot i_{ab}$, is then a positive quantity. If we now assume that the current is actually from a to b, i_{ab} is a positive quantity. Since the product of the voltage and the current, $e_{ab} \cdot i_{ab}$, is a positive quantity, e_{ab} is also a positive quantity. In Fig. 5, the electric circuit is right-handed from a to b, and thus the current is actually right-handed when observed from c. With such a current, the

flux is actually from c to d and thus ϕ_{cd} is a positive quantity. (See convention for flux and magnetizing current.) Since this flux, ϕ_{cd}, is a positive quantity that is diminishing in magnitude, the rate of change of the flux with respect to the time, viz., $(d/dt)\ \phi_{cd}$, is a negative quantity. Since e_{ab} is a positive quantity and $(d/dt)\phi_{cd}$ is a negative quantity, we must write:

$$e_{ab} = -N\frac{d}{dt}\phi_{cd}.$$

N is the number of turns between a and b with which the flux, ϕ_{cd}, links.

That is, looking along the flux, ϕ_{cd}, the rise in electromotive force is right-handed through the circuit from a to b if we write:

$$e_{ab} = -N\frac{d}{dt}\phi_{cd}.$$

When observed from c the electric circuit is left-handed from b to a.

$$e_{ba} = -e_{ab} = N\frac{d}{dt}\phi_{cd}.$$

That is, looking along the flux, ϕ_{cd}, the rise in electromotive force is left-handed through the circuit from b to a if we write:

$$e_{ba} = N\frac{d}{dt}\phi_{cd}.$$

The time phase relationship of flux and generated electromotive force for the case of simple harmonic functions is determined as follows:

$$\phi_{cd} = \Phi_{cd}\ \sin\omega t,$$

$$e_{ab} = -N\omega\Phi_{cd}\ \cos\omega t,$$

$$e_{ba} = N\omega\Phi_{cd}\ \cos\omega t.$$

The vector, E_{ab}, representing the rise in generated electromotive force through the electric circuit due to electromagnetic induction, is ninety degrees behind the flux.

If the flux, ϕ_{cd}, is produced solely by a current, I_{ab}, which is right-handed in the circuit and is thus in time phase with the flux, the rise in generated electromotive force, E_{ab}, is ninety degrees behind the current, I_{ab}. This generated electromotive force is numerically equal to the reactive drop, XI_{ab}, which is itself ninety degrees ahead of the current. (See Fig. 7.)

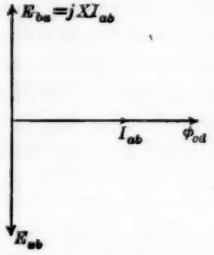

FIG. 7.

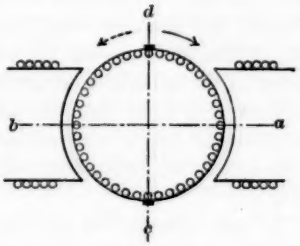

FIG. 8.

"Rotation" Electromotive Force.—This electromotive force is produced in commutating motors of which there are many types. It is due to the rotation of the armature inductors in the air-gap flux and acts between segments of the commutator which are directly connected to inductors that lie in a plane perpendicular to the axis of the air-gap flux. This is represented diagrammatically in Fig. 8. The "rotation" electromotive force acts through the armature winding between the brushes at c and d, if we assume that these brushes are in direct connection, through the commutator, with armature inductors lying in a plane perpendicular to the axis of the flux, $a-b$.

In determining the phase relation of the "transformer" electromotive force and the flux which produces it, it is necessary to state whether the electric circuit is right- or left-handed from one terminal to the other when observed in the direction in which the flux is taken. In the case of a commutator motor the circuit through the armature winding from the brush at

c to the brush at *d* may be either right- or left-handed depending upon the connections between the inductors and the segments of the commutator. If the manner of this connection were known we could determine in a given case whether the brush at *d* is at a higher or lower potential than the brush at *c*. It would be necessary to know this only when making an electrical connection between the brushes and some other related electric circuit. When such a connection is necessary it should be stated, for example, that the connection to the brushes is made so that the current, I_{pq}, in the related circuit, is right-handed in the armature winding when observed in the direction from *c* to *d*, or, that the electromotive force, E_{pq}, in the related circuit acts in a direction which is left-handed through the armature winding when observed in the direction from *c* to *d*.

It is most common to represent the electromotive force of "transformer" action as ninety degrees behind the flux which produces it. This presupposes that the rise in electromotive force is taken in a direction which is *right-handed* through the circuit when observed in the direction in which the flux is taken. In order that the convention for the "rotation" electromotive force will be in accord with this it will *always* be represented as the rise in potential in a direction which is *right-handed* through the armature winding when observed in a stated direction along the line of the brushes.

To distinguish between the "transformer" and the "rotation" electromotive forces an additional subscript may be used. E_{cd} designates the "transformer" electromotive force and E_{Rcd} the "rotation" electromotive force.

Rotation Electromotive Force.—E_{Rcd} is the rise in "rotation" electromotive force in a direction which is right-handed through the armature wnding when observed in the direction from *c* to *d*. If E_{Rcd} is a negative quantity, the electromotive force is actually left-handed when observed in the direction from *c* to *d*, or is right-handed when observed in the direction from *d* to *c*. When E_{Rcd} designates a vector the electromotive

force is actually right-handed, when observed in the direction from c to d, during the time the projection of E_{Rcd} on the time axis is positive.

There should also be a similar convention for the current in such a circuit. Thus, when I_{cd} represents the current in the armature of a commutating motor, it is taken as right-handed when observed in the direction from c to d. This current would therefore produce a flux from c to d.

The phase relation of the "rotation" electromotive force, E_{Rcd}, and the flux, ϕ_{ab}, which produces it is determined by the direction of rotation in the following manner: Consider Fig. 8.

Let the armature rotate right-handed as shown by the full line arrow. During the time the flux is actually from a to b, *i. e.*, while ϕ_{ab} is a positive quantity, the "rotation" electromotive force, E_{Rcd}, is actually right-handed when observed in the direction from c to d and is also a positive quantity. Therefore, for this direction of rotation, E_{Rcd} is in time phase with ϕ_{ab}.

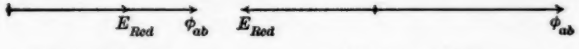

FIG. 9.

Now consider that the armature is rotating left-handed as shown by the dotted arrow. During the time the flux is actually from a to b, *i. e.*, while ϕ_{ab} is a positive quantity, the "rotation" electromotive force, E_{cd}, is actually left-handed when observed in the direction from c to d and is thus a negative quantity. Therefore, for this direction of rotation, E_{Rcd} is in time opposition to ϕ_{ab}. The vector diagrams are shown in Fig. 9.

If the angle between the armature current I_{ab} and the rotation voltage E_{Rab} is less than ninety degrees electrical power is developed, but if this angle is greater than ninety degrees mechanical power is developed.

What advantages this notation may possess become more apparent when it is applied to definite problems that are not too

simple. In some cases it may happen that the circuits are so interrelated that vector equations will have to be solved before a vector diagram can be drawn which shows the correct phase relations. The same notation applies equally well when writ-

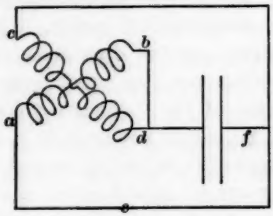

FIG. 10a.

ing these equations. Another useful method of handling such a problem is to assume some value for the unknown phase angle. If there is no error in the completed vector diagram this assumption was correct.

The first problem relates to the combination of inductance

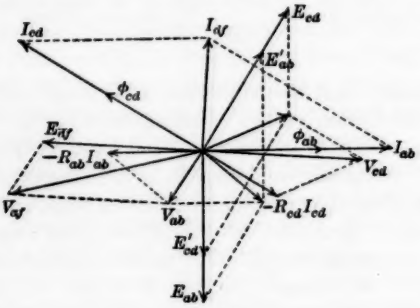

FIG. 10b.

and capacity which is shown in Fig. 10a. This arrangement is known as "Campbell's Wave Sifter." The coils *a*–*b* and *c*–*d* are both right-handed when observed in the direction *a* to *b* and *c* to *d* respectively. The coils *a*–*b* and *c*–*d* are also

right-handed when observed in the direction c to d and a to b respectively. At e is a harmonic electromotive force. The vector diagram is given in Fig. 10*b* in which the vectors are drawn in the following order. I_{ab}, ϕ_{ab}, E_{ab}, E_{cd}', $-R_{ab}I_{ab}$, I_{cd}, ϕ_{cd}, E_{cd}, E_{ab}', $-R_{cd}I_{cd}$, I_{df}, E_{df}, V_{ab}, V_{cd}, V_{af}. ϕ_{ab} is the flux produced by the current I_{ab} alone and ϕ_{cd} that produced by I_{cd} alone. E_{ab} is the voltage produced in the coil a–b by the flux ϕ_{ab} while E_{ab}' is that produced in a–b by the flux ϕ_{cd}. E_{cd} and E_{cd}' are produced by ϕ_{cd} and ϕ_{ab} respectively.

The terminal voltages V_{ab} and V_{cd} are

$$V_{ab} = E_{ab} + E_{ab}' - R_{ab}I_{ab}$$

and

$$V_{cd} = E_{cd} + E_{cd}' - R_{cd}I_{cd}.$$

The applied electromotive force is

$$V_{af} = V_{ab} + E_{df}.$$

It is necessary that the sum of E_{df} and V_{cd} should be zero.

The case of the auto-transformer with one coil reversed is interesting. The circuit diagram is given in Fig. 11*a*. The

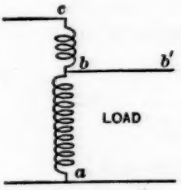

FIG. 11*a*.

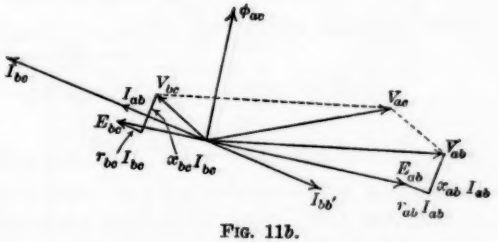

FIG. 11*b*.

coil a–b is right-handed and the coil b–c is left-handed when observed from a towards c. The coil a–b has a greater number of turns than the coil b–c. The vector diagram is given in Fig. 11*b*. The simple diagram which omits the exciting current is used.

The relation between the currents is established as follows:

$$I_{bb'} = I_{cb} + I_{ab},$$

since

$$I_{bc} = KI_{ab},$$

$$I_{bb'} = -KI_{ab} + I_{ab}$$

$$= (1 - K)I_{ab}.$$

K is greater or less than one as there are greater or fewer turns in the coil a–b than in the coil b–c. The order of drawing the vectors is, V_{ab}, $I_{bb'}$, I_{ab}, $x_{ab}I_{ab}$, $r_{ab}I_{ab}$, E_{ab}, ϕ_{ac}, E_{bc}, I_{bc}, $r_{bc}I_{bc}$, $x_{bc}I_{bc}$, V_{bc}, V_{ac}.

The interesting point in this problem is that the reversal of the coil b–c reverses the action of both coils. a–b now receives electric energy and b–c delivers electric energy, whereas with the usual arrangement the coil a–b delivers energy and b–c receives energy. If, however, there are more turns in the coil b–c than in a–b the reversal of one coil does not thus reverse the operation of the windings.

The third case is that of a compensated repulsion motor. The arrangement of the circuits is shown in Fig. 12*a*.

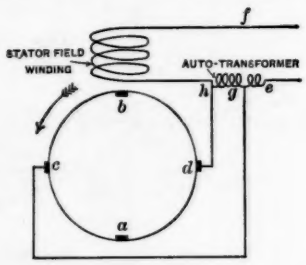

FIG. 12*a*.

The brushes on the axis $a - b$ are short circuited. The stator winding is right-handed from h to f when observed in the direction from a to b. The connections between the armature coils and the commutator segments are so made that an

actual rise in voltage from g to h will produce a current which is actually right handed in the armature when observed in the direction from c to d.

The vector diagram is given in Fig. 12*b*. In order to simplify the diagram slightly it is assumed that the exciting currents which produce the fluxes ϕ_{ab} and ϕ_{cd} are in phase with them. The exciting current in the auto-transformer is neglected. The ratio of transformation between the stator and rotor windings on the axis a–b is taken as unity. The currents in these windings are respectively I_{ab}' and I_{ab}''. $I_{\phi ab}$ is the exciting component of the current in the stator winding. E_{Tcd} is the voltage due to the flux ϕ_{cd}.

In order to determine the phase relation between the currents I_{ab}' and I_{ab}'' it is necessary to solve a simple vector equation.

$$I_{ab}' + I_{ab}'' = I_{\phi ab},$$

$$\phi_{ab} = k_1 I_{\phi ab},$$

$$E_{Tab} = -jk_2\phi_{ab} = -jKI_{\phi ab}$$

$$= -jK(I_{ab}' + I_{ab}'').$$

The voltage equation for the armature circuit a–b is:

$$E_{Rab} + E_{Tab} = I_{ab}''(R_{ab} + X_{ab}).$$

R_{ab} and X_{ab} are the resistance and leakage reactance of the rotor winding.

$$E_{Rab} - jK(I_{ab}' + I_{ab}'') = I_{ab}''(R_{ab} + X_{ab}).$$

Thus:

$$I_{ab}''(R_{ab} + j(X_{ab} + K)) = E_{Rab} - jKI_{ab}'. \qquad (1)$$

If the exciting current in the auto-transformer is neglected the currents I_{cd} and I_{ab}' must be in phase. E_{ab} will thus be in phase with I_{ab}' since it is assumed that ϕ_{cd} is in phase with I_{cd}. These conditions make it possible to determine the rotor current I_{ab}'' from equation (1).

The order of drawing the vectors in Fig. 12*b* is: I_{ab}', I_{cd}, ϕ_{cd}, E_{Tcd}, E_{Rab}, $-jKI_{ab}'$, I_{ab}'', $I_{\phi ab}$, ϕ_{ab}, E_{Tab}, E_{Rdc}, $R_{cd}I_{cd}$, $X_{cd}I_{cd}$, E_{gh}, E_{eh}, E_{ef}, $R_{ab}'I_{ab}'$, $X_{ab}'I_{ab}'$, V_{ef}.

R_{ab}' and X_{ab}' include the resistance and leakage reactance of the stator field winding and the auto-transformer.

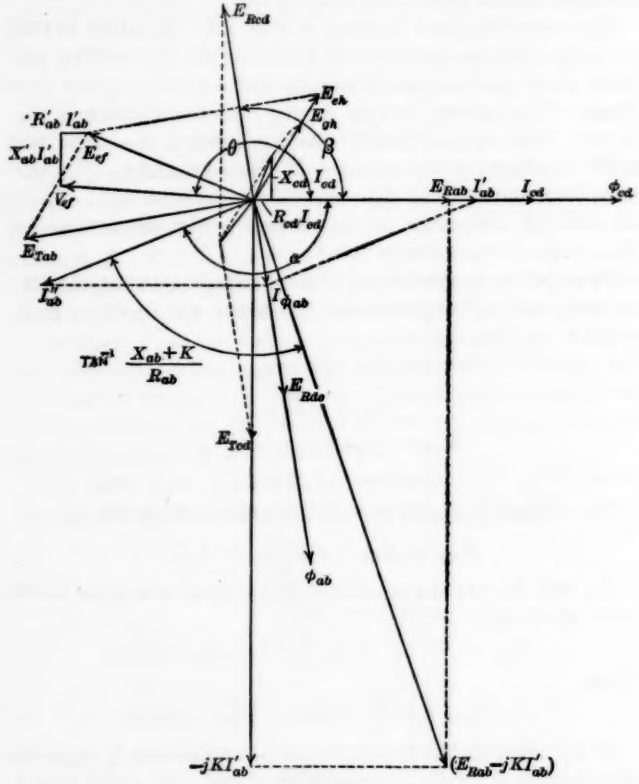

FIG. 12*b*.

The input to the motor is:

$$P_i = V_{ef} \cdot I_{ab}' \cdot \cos\theta.$$

The mechanical power developed is

$$P_m = E_{Rab} \cdot I_{ab}'' \cdot \cos\alpha + E_{Rcd} \cdot I_{cd} \cdot \cos\beta.$$

COMPOUND TECHNICAL TERMS.

BY D. E. CARPENTER,

Manager of Education, International Textbook Company, Scranton, Pa.

The compounding of technical terms is a subject of much interest among technical writers and publishers, and the article by Professor Park in the November BULLETIN is a valuable addition to the discussion thereon. It is improbable, however, that any plan of compounding can be devised that will be of universal application or that will be generally followed by publishers, for several reasons.

Every publishing house has its style code that is strictly followed unless good reasons are found for departing from it in rare cases. This practice has resulted in a considerable degree of uniformity in the style of publications of each house and has become so well understood by its employees that they follow it without the loss of time necessary to consult authorities. This style is not always consistent, which seems practically impossible, but it gives uniformity and efficient use of time. It has become so firmly established that the publisher would be seriously inconvenienced by a sudden change to the practice of others or to a plan devised for general uniformity. Such a plan would probably introduce, at least temporarily, many glaring inconsistencies and would decrease the efficiency of employees.

Any plan proposed for general use would probably meet the fate of the reformed spelling so strongly advocated a few years ago. Many of the new forms were simpler than the old, but despite this and the fact that many prominent men advocated their adoption, the attempt was a complete failure so far as any material immediate results were concerned. The President of the United States even issued an executive

order that the new spelling should be used for all publications issued by the government printing office. Perhaps this order resulted in the use of a comparatively few of the new forms, but no very noticeable change of practice has been discernible.

All living languages are subject to slow change, and the change in the compounding as well as in the spelling and meaning of terms will go on despite all rules and regulations that can be devised to fix them permanently. When English is a dead language like Latin, its compounds will be fixed and not before. It is not essential for those who have graduated from school and are not engaged in some literary calling to keep on studying all their lives just in order to be familiar with the latest spring styles in spelling or compounding. Probably all of us can recall terms that were considered good usage when we went to school and that we continue to use although we may know that a slightly different form is in vogue at the present time. The forms our children are learning at the present time will also be used by them in later life.

How many of us care whether we write *draught* instead of the shorter and simpler word *draft* that our children now use? Why should we worry if we write *to-day* in the compound form when our children write the solid form *today*, which is considered good practice at the present time, although the solid form has not come into general vogue. It will do so in time, however, and a great many of the compounds that we now try to fix as permanent will do likewise. If, in spite of these facts, we still think it is possible to establish standard forms, where shall we look for a basis for formulating rules? Dictionary makers have attempted this and failed. Are engineers better qualified by training to accomplish something that others who have given years of study to the subject have failed to do? And if by some miracle a logical system could be formulated, how can those who are past the school age be reached and persuaded to adopt the forms? Before many per-

sons would even see the forms, a hundred alleged better systems would be presented.

The only test that can be applied to compound terms is usage—*common* usage, not universal usage. The primary purpose of dictionaries is to record usage, and to some extent they do so; to some extent, also, arbitrary rules are followed. The result is that the number of inconsistencies is increased rather than reduced, and some of the forms violate the rules of grammatical construction. Curious inconsistencies occur with almost all classes of words. The following are a few of the typical examples: *woodwork, wood-worker, boilermaker, shoemaker, boot maker, globe valve, check-valve, setscrew, feed-screw, adjusting screw, earring, finger-ring, schoolroom, dining-room, bedroom, sewing room, foot-note, side note.*

There is a natural tendency to gravitate to solid forms of nouns when the two elements composing them can always remain joined, as in the names of occupations, such as boilermaker, shoemaker, etc. Only hair-splitting arguments, however, could justify such differences as *woodwork* and *wood-worker*. In terms of this kind, the hyphen is only a transitional stage between the two-word and the one-word form. The solid form of the term *woodwork* indicates that terms composed of these elements have reached their final form, and there appears to be no good reason why variations should revert to the transitional form. In this and similar terms the initial element has lost its distinction as an adjective, and therefore it may be joined to the second element by a hyphen; but, since the sense never or practically never requires the separation of the two elements, the solid form is better, as marking a permanent union. This is more clearly illustrated by the term *steamship*. When ships were first propelled by steam, it was necessary to use the word *steam* as an adjective to distinguish a *steam* ship from a *sailing* ship. This distinction is no longer necessary, and the identity of the adjective has been completely lost in the noun. Other classes of words, however, do not lend themselves to this arrangement,

because two words joined by a hyphen become a compound noun, except in the case of compound adjectives, whereas the grammatical sense may require an adjective and a noun. The word *setscrew,* for instance, is given by dictionaries as a solid compound; this seems to be its logical form, and it is generally so written. However, in the same article and perhaps in the same paragraph it may be necessary to distinguish between different kinds of screws, as *adjusting* screw, *feed* screw, and *set* screw. In such cases, the forms laid down are inconsistent, and only one is grammatically correct. The incongruity of some compound forms is well illustrated by the term *head-course,* which is given as a hyphenated form, which makes it a compound noun. Properly, the term is *header* course, from which form it is apparent that an adjective and a noun are required to give the sense and no one with a discriminating taste will compound an adjective and a noun. Still another class of words requires a hyphen to distinguish the compound noun from the adjective, and if the form of the compound is laid down, we have the choice, in certain cases, of either disregarding it or using a form that expresses something entirely different from that intended. This is illustrated by the term *car-heater,* which is laid down as a compound, when it is preceded by the adjective *electric.* Thus, if we write *electric car-heater,* the meaning of the expression is that the car-heater is an electric apparatus, and if this is what is intended, the form is the only one that exactly expresses the meaning. If, however, the heater, which may be a stove, is for an electric car, the position of the hyphen must be changed, and the expression written *electric-car heater.*

Instances of the same nature as those described could be given indefinitely, but it should be clear from what has been said that no basis for the standardization of compound terms can be found. The only results of an attempt to fix forms of compounds is usually further confusion and loss of time that could be more profitably given to more important matters. In fact, if most of the so-called rules for compounding

were abolished and the plan adopted of using hyphens in the same way that marks of punctuation are used, that is, according to the sense required, a long step in the right direction would be made. The only rule of general application is the one that requires any two or more words used as a single adjective to be joined by a hyphen.

The publishing house with which the writer is connected has a practical system that has received general approval. Compound terms are printed solid if so given by the Standard Dictionary and also a few that are authorized by other good authorities. Two or more words that form an adjective when combined are hyphenated. Compound nouns are hyphenated when this practice is almost universal, as with compounds beginning with *self*. Nouns that when combined express a quantity, as foot-pounds, are also hyphenated. In other cases compound nouns are written as separate words. This plan does not secure absolute consistency nor is it perfect; but it has worked very satisfactorily for a good many years. The effort to improve the consistency of the style has caused a list of exceptions to grow, but those who prepare copy have little trouble in remembering most of them. Occasional lack of strict uniformity in the hyphenating of expressions rarely used is not considered serious.

THE TASK FOR THE TEACHER.

BY FRANK E. SANBORN,

Director Industrial Arts Department, The Ohio State University.

These are the days when one reads and hears much of scientific management. It has been concerned with the individual who works in the industries, has measured his work and has altered methods to secure a quickening of the operation performed, and an increase of the products. It has done this with the welfare of the worker in mind, and has increased his financial recompense, thus lessening the nervous strain due to money troubles, and has reduced the working strain upon him, so that the fatigue of the work itself is cared for as the work goes on, and the energies of the worker are conserved.

The same general system should be applied to the teacher, since it is not right that a teacher should be forced or allowed to carry so much class work that he is obliged to take to a hospital for rest and treatment at the end of the academic year, or that he is so fagged out that, even at the end of two or three months' vacation (?), he has not regained his energies for another year's work.

There should be some method by which presidents, deans and others in authority can get some estimate of the amount of work laid upon their teachers. There should be some maximum of hours for a teacher's work, when all his duties are those pertaining to teaching.

The equations given here are an attempt to furnish a standard for comparison. It is not thought that it can be an absolute standard, althought it is nearer to that than the use of no method. It is perhaps relative, and, if applied, will show quite plainly who is carrying a light load and who is overloaded. It is thought that the full task for a teacher should

not use more than 35 hours a week of his time as computed by these formulæ. A laborer's work is frequently 54 hours per week. A student's time for 18 credit hours is usually considered as 54 hours. The hours of the day for college exercises are around 39 hours. The 35 hours of the teacher will give some time for the daily physical exercise, so necessary to counteract his sedentary habits, and for other study than that needed in daily preparation for the class room.

It is thought that a man who is the head of a department, or who is interested in doing research work, or who has considerable ability as a writer, or who has thesis work to direct, or who needs some time for the practice of his profession, or who has much committee work, should have his task-hours per week reduced somewhat, depending upon the special duties mentioned. The supervision of some departments calls for more time than that of others. Some lines of research can be followed out by a few minutes each day, while others call for elaborate preparation and tests during many continuous hours.

SUGGESTED EQUATIONS FOR ENGINEERING WORK.

Method of Instruction.	Minimum Hours a Week the Teacher Would Probably Need for a Subject.
Lectures only	$(1 + N + 0)H$
Recitations only	$(1 + N + 0)H$
Lectures and recitations combined with problems to be corrected	$(1 + N + S/15)H$
Drawing or designing	$(\frac{1}{3} + N + S/30)H$
Shopwork laboratories or chemical laboratories	$(0 + N + S/100)H$
Physical laboratories or mechanical laboratories or electrical laboratories or field work, etc.	$(\frac{1}{3} + N + S/50)H$

N = number of sections in a subject,

H = clock hours a week per section per subject,

S = students in the subject, whose written work, or equivalent, is corrected or graded by the teacher under consideration.

There are given herewith some applications of these equations to actual teaching conditions:

Professor A.—Head of a department which calls for a very little time to direct it.

First semester.

3 sections. 90 students. 5 hrs. a week. Lect. and recit. Work graded by an assistant.

$$(1+3+0)5=20 \text{ hrs.}$$

Second semester.

3 sections. 60 students. 5 hrs. a week. Lect. and recit.
1 section. 27 students. 2 hrs. a week. Lect. and recit.
All this work graded by an assistant.

$$(1+3+0)5=20 \text{ hrs.}$$
$$(1+1+0)2=\ 4 \text{ hrs.}$$
$$\overline{24} \text{ hrs. a week.}$$

He claims that his work is carried easily and that he has time for textbook writing or some research.

Professor B.—Professor in a department.

First semester.

1 section.	8 students.	2 hrs. a week.	Lect. and recit.
1 section.		1 hr. a week.	Lect. purely.
1 section.	8 students.	6 hrs. a week.	Lab.
1 section.	6 students.	6 hrs. a week.	Lab.
1 section.	11 students.	4 hrs. a week.	Lab.

$$(1+1+\tfrac{8}{15})2=\ 5.07$$
$$(1+1+0)1=\ 2$$
$$(\tfrac{1}{3}+1+\tfrac{8}{50})6=\ 8.94$$
$$(\tfrac{1}{3}+1+\tfrac{6}{50})6=\ 8.70$$
$$(\tfrac{1}{3}+1+\tfrac{11}{50})4=\ 6.20$$
$$\overline{31.91} \text{ or } 32 \text{ hours.}$$

He says that the work of this semester is fair in amount and that he can do justice to his students; but that he cannot do any research work, as such work in his subjects would call for extended and continuous time.

Second semester.

10 students.	12 hrs. a week.	Lab.	
	8 hrs. a week.	Lab.	Work examined by an assistant.

	4 hrs. a week.	Lab.	Work examined by an assistant.
13 students.	2 hrs. a week.	Lect. and recit.	
30 students.	3 hrs. a week.	Lect. and recit.	
27 students.	1 hr. a week.	Lect. and recit.	

Theses ?

$(\frac{1}{3}+1+\frac{1}{50})12=18.36$
$(\frac{1}{3}+1+0)8=10.67$
$(\frac{1}{3}+1+0)4=5.33$
$(1+1+\frac{13}{15})2=5.77$
$(1+1+\frac{3}{15})3=12$
$(1+1+\frac{27}{15})1=3.8$

$\overline{55.13}$ hrs. per week + theses time.

He claims that it is impossible to carry this semester's work in a proper manner, that he has to slight both the work and the students. The semester's work is very unsatisfactory.

Professor C.—Head of a department, the direction of which calls for a good deal of time, estimated at 15 hrs. a week.

First semester.

2 sections.	31 students.	5 hrs. a week.	Lect. and recit.
2 sections.	37 students.	3 hrs. a week.	Lect. and recit.

Work of about half the students examined by assistant.

$(1+2+\frac{15}{15})5=20$
$(1+2+\frac{15}{15})3=12$

$\overline{32}$ hrs. a week.

The time needed for department work exceeds the remaining three hours. Some of this department work is omitted or not done thoroughly.

Second semester.

1 section.	30 students.	3 hrs.	Lect. and recit.
1 section.	30 students.	6 hrs.	Drawing.
1 section.	29 students.	3 hrs.	Lect. and recit.
1 section.	29 students.	3 hrs.	Drawing.
1 section.	25 students.	2 hrs.	Lect. and recit.

1 section. 15 students. 2 hrs. Lecture with some student problem work.

$(1+1+{}^{30}/_{15})3=12$
$(\frac{1}{3}+1+{}^{30}/_{30})6=14$
$(1+1+{}^{29}/_{15})3=11.8$
$(\frac{1}{3}+1+{}^{29}/_{30})3=\ 6.9$
$(1+1+{}^{25}/_{15})2=\ 7.33$
$(1+1+{}^{15}/_{15})2=\ 6$
$\overline{58.03}$

He states that it is impossible to carry his class work in a proper manner, not counting the demand upon his time as head of the department.

Professor D.—

2 sections. 1 hr. a week. Lecture and recit. No grading of papers.

3 sections. 1 hr. a week. Lecture and recit. No grading of papers.

3 sections. 5 hrs. a week. Lab. (shop),

$(1+2+0)1=\ 3$
$(1+3+0)1=\ 4$
$(3+{}^{48}/_{100})5=17.40$
$\overline{24.40}$ hrs. a week.

This professor has had time for research work.

Mr. E.—

6 sections. 1 hr. a week. Lect. and recit. No grading of papers.

9 sections. 4 hrs. a week. Lab. (shop). 151 students.

As this instructor has a full-time assistant, it would be fair to call his time

$(1+5+0)1=\ 6$
$(0+9+{}^{75}/_{100})4=39$
$\overline{45}$ hrs. a week -5 hrs. $=40$ hrs. week.

This work is easily carried; part of the time the assistant is alone with the class, as the instructor is attending classes (5 hours) in other subjects for his own improvement.

The above are cited as typical cases. It is evident from these that the time required of the different men is very unequal. If these cases exist in one college, it would seem to call for a readjustment of duties on the part of the dean or a different distribution of assistants and instructors; the 58-hr. man can hardly be blamed if he became somewhat distressed over these inequalities. It is not enough to say that the 20–24 hr. man is devoting his spare time to research or to text-book writing. Should he be given so much spare time when another, equally capable, is heavily burdened? At least he should be asked to correct his own exercises and the salary of his assistant used for an assistant to some one else.

There is one case in mind relating to two professors; one carried light work, wrote text-books and so made a name for himself outside of the institution in which he was located. The students never found him sympathetic, or helpful, or clear, in his classroom work. The other carried a heavy burden; being assigned so much work that he could not get time to write many books. The notes arranged for his classes were excellent and he could have written very successful text-books, or could have done excellent research work. His students all found him a helpful friend and a good teacher. As a result, the former was advanced in honor and salary, and the latter continually overloaded, and without any advance in salary. Was it fair? Perhaps it was not intentional but would it not have been well for the president to have had a basis of comparison of the time exacted of his professors?

In the suggested equations it is understood that the hour of preparation is for the cases where the subject is well in hand. If a new course is being prepared, it is granted that much more time will be needed. It is thought that the one hour would be a good average.

It may be claimed that a college has not enough money to secure the necessary number of teachers and assistants. This is the usual complaint. If so, it would seem that at least the teaching work of those instructors who are in the college

should be more nearly equalized. Possibly the teachers who are carrying light teaching work, while their associates are heavily loaded, would be willing to do their proper proportion of the teaching if their pay would otherwise be reduced.

Some contend that a university or college should carry on research work. That is well, but it is a matter of opinion as to whether its first duty and chief object should be proper instruction of students, who have come to it for instruction and training, or whether it should be research work. Happy is that college which has funds adequate for both of these. There are very few men in the teaching profession who would not like to carry on research work, and who, by such work, would not be benefited personally and as teachers. Each teacher where possible should be allowed some time for such work. If a teacher is allowed time for research work, he should be expected to give some account of his work and of the time spent upon it, even if the results are negative.

It is hoped that these equations will be tried out in different colleges. If they do not represent the facts, perchance others may be found that will do better. But a spirit of fair dealing calls for some action.

THE ENERGY EQUATION OF TURBINES.

BY R. F. DEIMEL,

Assistant Professor of Mechanics, Stevens Institute of Technology.

Sometimes the endeavor to make the mathematical part of mechanics clear and simple results in making it long and tedious. To follow a long, "easy" explanation too frequently demands an amount of concentration fully commensurate with the more intensive thinking required to understand a briefer and possibly more "difficult" argument; the former is as great a strain on the student's attention as the latter is a drain on his stock of knowledge. The customary method of obtaining the energy equation of turbines is a case in point: it involves the theorem of angular momentum, Bernouilli's theorem, and the properties of the velocity triangles at entrance and exit. This is unquestionably excellent practice and review but the following discussion—which is intended as a contribution to pedagogy rather than to hydraulics—depends on the very principles underlying Bernouilli's theorem and that of momentum, and therefore has advantages of its own.

Fig. 1 shows an element of water of volume $ds\ dA$ moving on a vane which rotates at constant angular velocity ω. The motion of the particle with respect to the vane, i. e., its relative motion, is produced by the change of coördinates ρ, θ. By the principle of superposition the tangential acceleration is composed of two parts: dv/dt, the scalar change of relative tangential velocity, and $\rho\omega^2$, due to the rotation of the particle. These, with the applied forces, are shown in Fig. 2. If w is the weight per unit volume, and friction and change of head are neglected

$$\frac{\delta p}{\delta s}\, ds dA = \frac{w}{2g}\, ds dA \left(\rho\omega^2 \cos\psi - \frac{dv}{dt}\right).$$

Putting $\cos\psi = d\rho/ds$ and integrating between limits, we have

$$p_2 - p_1 = \frac{w}{2g}(r_2^2 - r_1^2)\omega^2 - \frac{w}{2g}(v_2^2 - v_1^2), \qquad (1)$$

where v_1, v_2 are the *relative* velocities at entrance and exit and r_1, r_2 the corresponding radii.

FIG. 1.

FIG. 2.

If full flow is not maintained, as in an impulse wheel, $p_1 = p_2$ and thus

$$v_2^2 - v_1^2 = \omega^2 (r_2^2 - r_1^2). \qquad (2)$$

It has been attempted* to drive eq. (2) by arguing that since the left member represents the gain of kinetic energy to an observer on the wheel and the right member the gain as seen from the earth, the two are equal. It seems to me that the argument fails because it has not been shown that both observers are looking at the same thing. But why shouldn't the observer on the earth see the gain in absolute energy and he on the vane the work done in the displacement of a particle relative to the vane? It will now be proved that these two quantities are not equal and that the relation between them can be obtained directly from the velocity triangle at entrance or exit.

* Merriman, *Hydraulics*, 1910, § 151.

Call R and P in Fig. 3 the component forces, *per unit mass*, measured along and perpendicular to the radius vector, taken positive in the sense of increasing ρ and θ; R and P include the applied forces, the reactions, and friction. The corresponding acceleration components are

$$a_r = \ddot{\rho} - \rho(\dot{\theta} + \omega)^2$$

$$a_p = \frac{1}{\rho}\frac{d}{dt}[\rho^2(\dot{\theta} + \omega]).$$

The total time-rate of work per unit mass for the absolute displacements $d\rho$ and $\rho\ (d\theta + \omega dt)$ is

$$\frac{dW}{dt} = R\dot{\rho} + P\rho(\dot{\theta} + \omega)$$

$$= \frac{1}{2}\frac{d}{dt}[\dot{\rho}^2 + \rho^2(\dot{\theta} + \omega)^2]$$

$$= \frac{1}{2}\frac{d}{dt}V^2, \tag{3}$$

where V is the absolute velocity of the particle.

If dW_r/dt is the rate of relative work, *i. e.*, the work done per unit time by the forces R and P in the displacements $d\rho$ *and* $\rho d\theta$ along the vane, and if ω is constant

$$\frac{dW_r}{dt} = R\dot{\rho} + P\rho\dot{\theta}$$

$$= \frac{1}{2}\frac{d}{dt}[\dot{\rho}^2 + \rho^2\dot{\theta}^2 - \rho^2\omega^2]$$

$$= \frac{1}{2}\frac{d}{dt}(v^2 - u^2), \tag{4}$$

where v is the velocity of the particle relative to the vane and u the velocity of that point on the vane itself where the particle happens to be.

The relative work can be transformed also as follows:

$$\frac{dW_r}{dt} = \ddot{\rho}\dot{\rho} - \rho\dot{\rho}(\dot{\theta}+\omega)^2 + \dot{\theta}\frac{d}{dt}[\rho^2(\dot{\theta}+\omega)]$$

$$= \frac{1}{2}\frac{d}{dt}V^2 - \omega\frac{d}{dt}[\rho^2(\dot{\theta}+\omega)]$$

$$= \frac{1}{2}\frac{d}{dt}V^2 - \omega\frac{dA}{dt}, \qquad (5)$$

where A is the angular momentum of the particle.

FIG. 3.

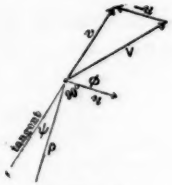

FIG. 4.

The second term $\omega\dot{A}$ in (5) is the rate of work dW_0/dt for the displacement $\rho\omega dt$ of the vane, assuming the particle at rest on it. That is,

$$\frac{dW_0}{dt} = P\rho\omega$$

$$= \omega\frac{d}{dt}[\rho^2(\dot{\theta}+\omega)]$$

$$= \omega\frac{dA}{dt}. \qquad (6)$$

From the identities (4) and (5), or from (3), (4) and (6),

$$V^2 = v^2 - u^2 + 2\omega A \qquad (7)$$

This can be obtained directly from the velocity triangle in Fig. 4 which gives

$$v^2 = V^2 + u^2 - 2uV\cos\phi; \qquad (8)$$

but $$u = \rho\omega \text{ and } A = \rho V\cos\phi,$$

whence eq. (7). It should be observed that the negative sign before the vector $(-u)$ in Fig. 4 is used only in vector relations and does not enter the scalar equation (8).

Equation (4) corresponds to (1) but is slightly more general. If there are no applied forces, as in an impulse wheel where the pressure is constant, and no friction, the left member of (4) vanishes and by integrating between limits we get (2). There will be a difference in signs because R in Fig. 3 is opposite to the pressure-difference in Fig. 2. While the observer on the vane of an impulse wheel cannot see that work is being done he nevertheless sees a gain of kinetic energy. It may not be unfair to suppose that the expert observer on the earth knew this, for otherwise he would have looked at the absolute instead of the wheel velocities.

POSITIONS WANTED.

No. 918. Professor of Electrical Engineering desires a teaching position for next year. Three years in engineering and nine years teaching experience in a state university. At present engaged in study at leading engineering school. Has specialized in hydroelectric engineering and transmission. Age 36, married.

THE CLASSIFICATION, DENOTATION AND FILING OF ELECTRICAL ENGINEERING APPARATUS.

BY F. C. CALDWELL,

Professor of Electrical Engineering, The Ohio State University.

The electrical engineering laboratory holds a somewhat unique position among laboratories on account of the large number of individual pieces of apparatus which it contains. The mechanical laboratory has a few large machines, and a limited number of indicators and other measuring instruments. The chemical laboratory on the other hand has only a few individual pieces and large numbers of beakers, test tubes, bottles, etc., having no individuality. In the electrical laboratory, however, not only each generator, motor and transformer but every meter of whatsoever sort is an individual and must have its own record and history. Even the rheostats, resistance frames and battery cells need to have their own names.

These conditions make the question of classification, denotation and filing of great importance in the electrical engineering laboratory. To be sure, many pieces of apparatus, when received, have the maker's number, the use of which is sometimes retained in the laboratory, but these numbers are generally of many digits, thus wasting time whenever they are written; and they may be duplicated for different makers and have no relation to each other nor to the laboratory where they are being used.

At the Ohio State University this problem has been satisfactorily solved by establishing a complete system of notation covering all classes of apparatus where there are many units. Each notation consists of a letter or letters, to indicate the kind of apparatus and a number for the individual piece, thus *D* 27.

The following list gives the letter designations as adopted for the different kinds of apparatus:

GENERAL CLASSIFICATION OF APPARATUS.

A, open.
B, battery cells, Nos. 1–700 reserved for large batteries.
C, condensers, proposed class, not assigned.
D, dynamo machines, accession numbers.
E, A.C. Voltmeters, see list.
F, D.C. Voltmeters, see list.
G, millivoltmeters, classified by makers.
H, heating devices, furnaces, proposed class, not assigned.
I, A.C. Ammeters, see list, same for A.C. and D.C. ammeters and shunts.
J, D.C. Ammeters, see list, same for A.C. and D.C. ammeters and shunts.
K, combination and miscellaneous measuring instruments, numbers accession.
Kb, bridges.
Kg, galvanometers.
Kt, tachometers, etc.
L, induction coils, classes same as ammeters.
M, multipliers, voltmeter, same as instruments with which they belong.
N, multipliers, wattmeter, same as instruments with which they belong.
O, *P*, *Q*, *open*.
R, rheostats, see list.
S, shunts, see list (same as ammeters).
T, transformers, see list.
Ts, series measuring transformers.
Tp, potential measuring transformers.
U, *V*, open.
W, wattmeters, see list.
Wh, watthour meters.
X, *Y*, *Z*, open.

It will be observed that as far as possible the letters are initials or related thereto in such a way as to help the memory. It is of course quite practicable to largely extend this list of notations by combining two capital letters or a capital and a small letter; thus *Da*16 might be an A.C. dynamo.

The numbers used with the above letters to designate the individuals are sometimes simple accession numbers, each piece of apparatus as it comes in being assigned the next highest number. In most cases, however, it is possible to make better use of the numbers by allowing them to stand for capacity or some other characteristic.

The classifications given below are standard with us and most of them have been in successful use for several years. The use of the numbers to indicate the capacity of the apparatus has been found especially satisfactory, and probably would be used even more generally if the system were to be started over again. Thus, dynamo machines might be well grouped according as they were A.C. or D.C. or combination machines and then further by capacity.

The system of classifications given are subject to further extension when a given group of numbers are taken up, by using the same group of units and 10's in successive series of 100's, thus following *F*29 would come *F*110, *F*210 would come after *F*129, etc.

VOLTMETERS.

Alternating Current = *E*.

Numbers.	Usual Scale.	Range of Volts.
1 to 9		0 to 20
10 to 29	60 and 65 and 75	21 to 119
30 to 69	120 or 130	120 to 149
70 to 89	150	150 to 299
90 to 99		300 and above

Meters with one scale are given odd numbers; with two scales, even numbers. The lowest scale determines the number.

Direct Current = *F*.

Numbers.	Usual Scale.	Range of Volts.
1 to 9		0 to 3
10 to 39	3	3 to 4.9
40 to 49	5	5 to 12.9
50 to 69	15	13 to 149
70 to 89	150	150 to 299
90 to 99		300 and above

Instruments with three scales are given odd numbers, divisible by 3, as 3, 9, 15, 21, etc. With one scale, are given other odd numbers. With two scales are given even numbers. The lowest scale determines the number.

AMMETERS.

A. C. = *I*, D. C. = *J*.

Numbers.	Usual Scale.	Range of Amperes.
1 to 29	1 or 5	0 to 9
30 to 39	10	10 to 14
40 to 49	15	15 to 19
50 to 69	25	20 to 49
70 to 79	50, 60, 75	50 to 99
80 to 89	100	100 to 149
90 to 99		150 and above

DIAL RHEOSTATS = *R*.

Numbers.	Maximum Current.
1 to 19	0 to 2
20 to 39	2.1 to 3.9
40 to 59	4.0 to 5.9
60 to 79	6.0 and above
80 to 99	special shapes

TRANSFORMERS = *T*.

Numbers.	Range of Kilowatts.
1 to 19	0 to 3
20 to 39	3.1 to 5
40 to 59	5.1 to 10
60 to 79	10 to 20
80 to 99	above 20.

WATTMETERS = *W*.

Numbers.	Range of Kilowatts.
1 to 9	0 to below 0.3
10 to 39	0.3 to 0.9
40 to 59	1.0 to 1.9
60 to 69	2.0 to 4.9
70 to 79	5.0 to 9.9
80 to 99	10 and above

WATTHOUR METERS = *Wh*.

Same numbering as for wattmeters.

The satisfactory marking of the apparatus is a matter which has involved some experimentation. The dynamo machines have the numbers painted on the frames with gilt paint, one inch brass stencils being used. Rheostats and similar apparatus, mounted on wood bases, have 1 inch $\times$ $1\frac{3}{4}$ inch card holders, on which the resistance and current capacities are also given. Transparent celluloid strips are used to protect the cards. For the instruments, various methods have been used. Stamped brass tags screwed on are permanent but expensive and the numbers do not show up well. Painting the small numbers is expensive and difficult. Numbers stamped in the wood and filled with white lead work well on some woods but are too difficult to change in case of need. One fourth inch white paper letters and numbers stuck on very carefully and then shellacked over probably give as good results as anything, though some trouble due to their coming off is experienced.

It is perhaps needless to say that each piece of apparatus should have its own place on a shelf. That place should also have its mark and should be definitely located by wood strips tacked on the shelf. There is much to be said for placing measuring instruments on edge on the shelves, even when special strips are necessary to hold them in position.

Lists of all apparatus giving their numbers, capacities and locations should be posted and kept up to date. Description of the methods of classification with explanation should also be provided, which should be called to the attention of each group of new students as they come into the laboratory.

FRESHMAN COURSE IN ORIENTATION.

BY W. H. KENERSON,

Professor of Mechanical Engineering, Brown University.

The appalling number of failures among the students of our colleges, particularly in the freshman year, is a cause of much concern to educators. A general lack of information and a considerable positive misunderstanding exists among the students of the entering classes respecting administrative, social and academic matters. This fact contributes to the failure of many to appreciate and profit by the college course.

The following extract from an editorial in *The Dial,* October 14, 1915, is significant.

"Young men and women by the thousand start, voluntarily or under pressure, and more or less hopefully, on an academic course leading to innumerable delightful possibilities in the way of honors and distinctions and ultimate fame and fortune in the great world beyond; but how many there are that drop out of the race even before it is well begun! Any college graduate will easily recall dim memories of perhaps a dozen or more classmates of that intensely vivid period of his adolescence, the first term of freshman year, who speedily and rather unaccountably faded from his view with the falling of the autumn leaves or the coming of the Christmas holidays."

This is the story of much keen disappointment to both students and parents which in certain cases amounts almost to tragedy.

It is easy to assume that misunderstanding and lack of appreciation on the part of the students is due to poor mental equipment, to insufficient preparation, or to lack of serious purpose, but it is possible that, in part at least, the fault is with the college.

The college may exist for the "gifted survivors of a sifting process." If so, to throw a youth of eighteen on his own resources is the highest ideal of education. It is probable, however, that a little judicious guidance may considerably mitigate the sifting process without materially lessening the opportunity for the development of self reliance. The student fresh from the preparatory school is usually confronted by many new ideas presented in a most hap-hazard manner. It is small wonder that many students do not "find themselves" before the latter part of the college course. Brown University has long recognized the situation and has attempted to meet it by insuring personal contact with the instructors through small class groups and by a system of student advisors.

This year a systematic effort has been made to present the purpose and meaning of college study and college life through a new course called the freshman course in orientation. The object and method of conducting the course, as stated on each printed lecture syllabus, is as follows:

"The purpose of this course is to give to the men entering Brown University such information concerning the opportunities, aims, customs and regulations of the college as will help to make their four years of college life enjoyable and profitable.

"There will be no examinations and no assignments of outside work. Attendance is required.

"A syllabus with blank pages for notes will be given out at the beginning of each lecture. This is to be signed with the student's full name and, together with the notes, is to be submitted for inspection on the date stamped on the cover.

"In case of an unavoidable absence the student may apply for the syllabus at the office of the dean.

"At the end of each semester a complete set of syllabi must be submitted for final inspection."

The lectures are divided into two groups.

In the first group, among other things, the college organi-

zation is described, together with the duties of the administrative officers and committees, sources of information, and rules and regulations governing the students; the nature of the courses leading to the several degrees; scholarships, honors and prizes open to competition; the purpose and working of the various student organizations, etc. These lectures, which come at the beginning of the course, are intended to give definite information that will enable the student to quickly adjust himself to the new conditions in which he is placed.

The second group deals with the subjects in the college curriculum. The intent of these lectures is not to give an epitome of any particular course nor to elaborate any special phase of it but to describe in simple form the scope and value of the subject and its relations to other subjects. A few suggestions for general reading accompany the lectures.

A list of the lectures for the present college year follows:

GROUP I

General Advice and Instruction	Dean O. E. Randall
Opportunities and Obligations in College	Dean O. E. Randall
Aims of the College	President W. H. P. Faunce
Student Activities	Professor J. C. Dunning
Manners	Professor Thomas Crosby, Jr.
The Cause of Disease	Professor F. P. Gorham
Use of the Library	Professor H. L. Koopman
Methods of Study	Professor S. S. Colvin

GROUP II

English	Professor Thomas Crosby, Jr.
Languages other than English	Professor Camillo von Klenze
Ancient Literature	Professor J. F. Greene
Modern Literature	Professor L. T. Damon
Mathematics	Professor R. G. D. Richardson
Astronomy and Geology	Professor C. W. Brown
Chemistry and Physics	Professor P. B. Perkins
Biological Sciences	Professor A. D. Mead
Psychology	Professor S. S. Colvin
Engineering Sciences	Professor W. H. Kenerson
History	Professor William MacDonald
Social and Educational Sciences	Professor J. Q. Dealey
Political Science	Professor J. C. Dunning

FRESHMAN COURSE IN ORIENTATION.

Economic Science .....Professor H. B. Gardner
Art .....Director L. E. Rowe, Rhode Island School of Design
Religion .....President W. H. P. Faunce
Philosophy .....Professor B. C. Ewer
Relation of the Curriculum to Careers .....Professor S. S. Colvin
History of Brown University .....Justice Charles E. Hughes
(Read by Professor Thomas Crosby, Jr.)

The course is intended to constitute a survey of the entire curriculum, without reference to specific courses or department lines.

Each lecture is planned with the idea of making it a part of a consistent whole. A printed syllabus is given to each student before the lecture to assist him in following the speaker, to aid him in making appropriate notes, and to serve as a permanent record of the lecture. A typical syllabus follows:

THE AIM OF THE COLLEGE

PRESIDENT FAUNCE

I The origin of the American colleges—nine of them before the Revolution. The idea of the New England founders; training for one calling, subsequently extended to others. Education with purpose behind it. The heroic sacrifice of the founders. The old curriculum, uniform and rigid. The old paternalism and its results. Influence of Cambridge and Oxford.

II Later changes, due to the introduction of the elective system, to the influence of German ideas of research, and to the growth of athletic sports.

III What do we go to college for? The difficulty of giving an answer in one sentence, but the necessity of some answer. The comedy and tragedy of the aimless student. Divergent theories and their result.

1. Good fellowship, social initiation and knowledge of human nature. The truth and the error in this theory. The attrition of comradeship. The philosophy of hazing. The economic value of good manners and insight into other men's minds.
2. The ideal of vocational training. What the business man thinks of the college student. The narrow view of study, seeking only the immediately useful, "bread and butter studies." Vocational schools, their place and their danger. The difference between a liberal college and a professional school. The attitude

of the state universities. The broader meaning of vocation, and how to realize it.

3. The ideal of culture. "Something done through us, or in us?" The value of "useless studies," as of useless sports. The acquisition of a flexible mind, a broad horizon, a quick and generous sympathy, a high sense of honor, and reverence for the unseen. The isolation and obstinancy of a "one-track mind." The freedom and power of a cultivated mind.
   a. The value of the various studies in the modern college:
      (1) The studies dealing with nature:
         a. The natural sciences, as botany, zoölogy, biology geology
         b. The physical sciences, as astronomy, physics, mechanics, chemistry, engineering
      (2) The studies dealing with human nature:
         a. Language and literature, ancient and modern
         b. History, social and political science, economics, law
         c. Mathematics, philosophy, art, music, religion
   b. What sort of man, in outlook, attitude, and ideal, will devotion to the "humanities" produce? What sort of attitude toward institutions and reforms may result from scientific training? The contemporary lives of William E. Gladstone and Herbert Spencer.
4. Famous definitions of education, as a help toward our own definition of aim:
   a. Milton's definition, in terms of preparation for duty
   b. Butler's definition, in terms of adjustment to heritage
   c. Huxley's definition, in terms of fitness for achievement.
   d. Why am I here? "How the good ship found herself."

The results of the experiment have been gratifying. While it is too early to form an estimate of the permanent value of the course, the opinion of the students is indicated by the following extract from one of several editorials in the student paper, *The Brown Daily Herald*. "The Orientation Course, although in its infancy, has shown the university that it is an important and almost necessary part of the curriculum. Its popularity is gaining weekly among the new men. The information received is not only interesting but valuable. Such a course should be offered by the faculty to all students."

The best evidence of the helpfulness of the course is the approval of the students.

PROGRESS REPORT OF THE COMMITTEE ON ELECTRICAL ENGINEERING.

After conferences at which four members of the Committee were present, and correspondence with the other members, the following outline was determined:

1. Short contributions for the BULLETIN are invited as an interchange of information regarding methods or appliances employed in electrical engineering instruction; whatever may be novel and useful and suggestive to others will be particularly welcome. The invitation for such contributions is hereby made through the BULLETIN. Contributions should be sent to the chairman of the committee, Professor C. F. Scott, Sheffield Scientific School, Yale University, New Haven, Conn.

2. Discussion continued from last convention: Should direct current be taught first, followed by alternating current, or should alternating current be taught first, and direct current be considered as a special case? Discussion is nearly invited through the BULLETIN, contributions to be sent to the chairman of the Committee.

3. The best features in the college life of engineers who are now in practice. This information to be secured from graduates, capable of forming worth-while judgment, and who have been away from college a reasonable length of time. Requests will be made to certain companies which employ electrical engineering graduates, asking them to secure from these men answers to the following questions:

From your present point of view as you look back upon your life and development while in college, what do you consider benefited you most?

1. In the regular curriculum.

2. In other phases of your college life.

Please state the nature of your present work, the name of college and year of graduation.

It is not proposed to ask for a general dissertation on engineering education, but, on the other hand, to secure from certain men the particular items which are of most consequence,

in order that both teachers and students may regard their work from the point of view of the man who has gained the perspective which experience affords.

In order to make the undertaking too voluminous, only a limited number of requests are being issued. Additional replies, however, will be welcome from those who may take interest in the matter from reading the above statement.